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TRANSACTIONS

OF THE

AMERICAN

SURGICAL ASSOCIATION

VOLUME THE THIRTY-SIXTH

EDITED BY

JOHN F. BINNIE, M.D.

RECORDER OF THE ASSOCIATION

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Hearn, William Joseph
Johnston, George Ben
Murphy, John B.
Tiffany, Louis McLane

OFFICERS OF THE ASSOCIATION

ELECTED JUNE, 1918

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EDWARD MARTIN, M.D.

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1608 Spruce St., Philadelphia.

ASSISTANT SECRETARY

FRANCIS T. STEWART, M.D.,
311 South Twelfth Street, Philadelphia.

TREASURER

CHARLES H. PECK, M.D.,
30 West Fiftieth St., New York City.

ASSISTANT TREASURER

CHARLES N. DOWD, M.D.,
127 West Seventy-second Street, New York City.

RECORDER

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Rialto Building, Kansas City, Mo.

ASSISTANT RECORDER

WILLIAM D. HAGGARD, M.D.,
Nashville, Tenn.

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JOHN F. BINNIE, M.D.
SAMUEL J. MIXTER, M.D.
Ex-officio.

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PRESIDENT, SECRETARY, RECORDER, AND THE CHAIRMAN OF THE ADJUNCT LOCAL COMMITTEE OF ARRANGEMENTS, *ex-officio*.

COMMITTEE ON NECROLOGY, CREATED IN 1884.

(Report by Title.)

F. H. GERRISH, M.D., *Chairman*
JOHN B. ROBERTS, M.D.
W. W. KEEN, M.D.

Place of next meeting:
ATLANTIC CITY, N. J.,
JUNE 16, 17, 18, 1919

ADJUNCT LOCAL COMMITTEE OF ARRANGEMENTS

JOHN B. ROBERTS, M.D.
WILLIAM B. COLEY, M.D.
WILLIAM L. ESTES, M.D.

DELEGATES TO CONGRESS OF AMERICAN PHYSICIANS AND SURGEONS, WASHINGTON, D. C., 1919

WILLIAM H. CARMALT, M.D., DELEGATE
JAMES F. MITCHELL, M.D., ALTERNATE

LIST OF THE PRESIDENTS

OF THE

ASSOCIATION FROM THE TIME OF ITS INSTITUTION

ELECTED

1880. †SAMUEL DAVID GROSS, M.D., LL.D., D.C.L (Oxon.), LL.D. (Cantab.), LL.D. (Edin.)—Founder of the Association.
1883. †EDWARD MOTT MOORE, M.D., LL.D.
1884. †WILLIAM THOMPSON BRIGGS, M.D.
1885. †MOSES GUNN, A.M., M.D., LL.D.
1886. †HUNTER McGUIRE, M.D., LL.D.
1887. †D. HAYES AGNEW, M.D., LL.D.
1888. †DAVID WILLIAMS CHEEVER, M.D., LL.D.
1889. †DAVID W. YANDELL, M.D.
1890. †CLAUDIUS HENRY MASTIN, M.D., LL.D.
1891. †PHINEAS SANBORN CONNER, M.D., LL.D.
1892. †NICHOLAS SENN, M.D., Ph.D., LL.D.
1893. JAMES EWING MEARS, A.M., M.D., LL.D.
1894. FREDERIC SHEPARD DENNIS, M.D.
1895. †LOUIS McLANE TIFFANY, A.M. (Cantab.), M.D.
1896. JOHN COLLINS WARREN, M.D., LL.D. (Jefferson) Hon. F.R.C.S. (Eng.).
1897. †THEODORE F. PREWITT, M.D.
1898. WILLIAM W. KEEN, A.M., M.D., LL.D., Hon. F.R.C.S. (Eng. and Edin.).
1899. ROBERT F. WEIR, A.M., M.D., Hon. F.R.C.S. (Eng.).
1900. †ROSWELL PARK, M.D.
1901. †DE FOREST WILLARD, A.M., M.D., Ph.D.
1902. †MAURICE H. RICHARDSON, A.B., M.D.
1903. †NATHANIEL P. DANDRIDGE, M.D.
1904. †GEORGE BEN JOHNSTON, M.D.
1905. ALBERT VANDER VEER, M.D.
1906. †DUDLEY P. ALLEN, M.D., LL.D.
1907. WILLIAM H. CARMALT, M.D.
1908. C. B. G. de NANCRÈDE, A.M., M.D., LL.D.
1909. RUDOLPH MATAS, M.D.
1910. RICHARD H. HARTE, M.D.
1911. ARPAD G. GERSTER, M.D., Chir.D.
1912. CHARLES A. POWERS, A.M., M.D.
1913. WILLIAM J. MAYO, A.M., M.D., D.Sc., F.R.C.S. (Edin.), LL.D. (Tor.).
1914. GEORGE E. ARMSTRONG, C.M., M.D.
1915. ROBERT G. Le CONTE, A.B., M.D.
1916. SAMUEL J. MIXTER, S.B., M.D.
1917. THOMAS W. HUNTINGTON, A.B., M.D., LL.D.
1918. LEWIS S. PILCHER, A.M., M.D., LL.D.

† Deceased.

NOTICE

This volume of TRANSACTIONS contains the papers read before the Association at the Meeting held June 6, 7 and 8, 1918.

The Association assumes no responsibility for the statements and opinions published in this volume.

FELLOWS

OF THE

AMERICAN SURGICAL ASSOCIATION

JUNE, 1918

* Denotes Original Fellows.
† Denotes Senior Fellows.
‡ Denotes Deceased Fellows.

ELECTED

†1890. Abbe, Robert, M.D., 13 West Fiftieth Street, New York, Surgeon to St. Luke's Hospital. *Vice-President*, 1901. *Council*, 1908.

†1890. Allis, Oscar Huntington, A.M., M.D., 1604 Spruce Street, Philadelphia. Surgeon to the Presbyterian Hospital.

1902. Andrews, E. Wyllys, A.M., M.D., 2525 Prairie Avenue, Chicago, Ill. Professor of Surgery, Northwestern University Medical School; Surgeon to Mercy Hospital and Michael Reese Hospital; Attending Surgeon to Cook County Hospital; Consulting Surgeon to the Provident Hospital.

1916. Archibald, Edward William, B.A., M.D., C.M., 160 Metcalfe Street, Montreal, Canada. Lecturer in Clinical Surgery, McGill University; Assistant Surgeon, Royal Victoria Hospital; Associate Surgeon, Children's Memorial Hospital.

1901. Armstrong, George E., C.M., M.D., LL.D. (Queens), D.Sc. (Liverpool), 320 Mountain Street, Montreal. Professor of Surgery and of Clinical Surgery, McGill University; Surgeon to the Montreal General Hospital; Surgeon to the Western Hospital, Montreal. *President*, 1914.

1913. Ashhurst, Astley Paston Cooper, A.B., M.D., 811 Spruce Street, Philadelphia. Instructor in Surgery in the University of Pennsylvania; Associate Surgeon and Orthopedist to the Episcopal Hospital; Assistant Surgeon to the Philadelphia Orthopædic Hospital and Infirmary for Nervous Diseases.

ELECTED

1917. Balfour, Donald Church, M.B., M.D., Rochester, Minn. Associate Professor of Surgery, University of Minnesota; Surgeon to St. Mary's Hospital, Rochester.

1906. Barrow, David, M.D., 148 Market Street, Lexington, Ky.

†1882. Barton, James M., A.M., M.D., 32 North New Hampshire Ave., Atlantic City, N. J.

1915. Besley, Frederic A., M.D., F.A.C.S., 4515 Greenwood Avenue, Chicago, Ill. Professor of Surgery, Northwestern University Medical School; Attending Surgeon to the Wesley and Cook County Hospitals.

1900. Bevan, Arthur Dean, M.D., 122 S. Michigan Boulevard, Chicago. Professor and Head of the Department of Surgery, Rush Medical College, University of Chicago; Surgeon to Presbyterian Hospital.

1901. Binnie, J. F., M.B., C.M. (Aberdeen), *Recorder*, 1334 Rialto Bldg., Kansas City, Mo. *Vice-President*, 1907.

1918. Blair, Vilray Papin, M.D., 4654 Berlin Ave., St. Louis, Mo. Professor of Aural Surgery, Washington University Dental School; Associate in Surgery, Washington University Medical School; Visiting Surgeon, St. Luke's Hospital; Assistant Surgeon in St. Louis Children's Hospital and Barnes Hospital.

1906. Blake, John Bapst, A.M., M.D., 657 Boylston Street, Boston, Mass. Instructor in Surgery, Harvard Medical School; Assistant Surgeon to the Boston City Hospital; Surgeon to the Long Island Hospital and St. Elizabeth's Hospital, Boston, Mass.

1902. Blake, Joseph, M.D., 40 Avenue Henri Martin, Paris, France.

1901. Bloodgood, Joseph C., B.S., M.D., 904 North Charles Street, Baltimore, Md. Associate in Surgery in the Johns Hopkins University.

1901. Bosher, Lewis C., M.D., 422 East Franklin Street, Richmond, Va. Professor of Practice of Surgery, Medical College of Virginia; Visiting Surgeon, Memorial Hospital.

1913. Bottomley, John T., A.B., M.D., 165 Beacon Street, Boston. Surgeon-in-Chief, Carney Hospital.

†1890. Bradford, Edward Hickling, A.B., M.D., 133 Newbury Street, Boston. Surgeon to the Children's and the Samaritan Hospitals; Assistant Professor of Orthopedic Surgery, Harvard University.

ELECTED

1900. Brewer, George Emerson, M.D., 16 East Sixty-fourth Street, New York City. Professor of Surgery in College of Physicians and Surgeons, Columbia University; Surgical Director, Presbyterian Hospital; Consulting Surgeon to the Roosevelt, City, Woman's, Manhattan Eye, Ear, Nose, and Throat Hospitals, and to the Ophthalmic and Aural Institute. *Vice-President*, 1913.

1917. Brewster, George W. W., A.B., M.D., F.A.C.S., 213 Beacon Street, Boston, Mass. Associate in Surgery, Harvard Graduate School; Visiting Surgeon, Massachusetts General Hospital; Consulting Surgeon to Frost Hospital, Chelsea, Mass.; Leonard Morse Hospital, Natick, Mass.; Milford Hospital, Milford, Mass.

1915. Brinsmade, W. B., A.B., M.D., 85 Montague Street, Brooklyn, N. Y. Professor of Surgery, Long Island College Hospital; Surgeon to Long Island College and St. John's Hospitals; Consulting Surgeon to St. Christopher's Hospital.

1911. Bruce, Herbert A., M.D. (Toronto Univ.), L.R.C.P. (London), F.R.C.S. (England), 64 Bloor Street East, Toronto, Canada. Associate Professor of Clinical Surgery, University of Toronto; Surgeon to the Toronto General Hospital.

1911. Buchanan, J. J., A.M., M.D., Ph.D., 1409 N. Highland Avenue, Pittsburgh, Pa. Professor of Surgery, University of Pittsburgh; Surgeon to Mercy Hospital and to Columbia Hospital.

1900. Bunts, Frank E., M.D., 1021 Prospect Street, Cleveland, Ohio. Professor of Principles of Surgery and Clinical Surgery in Medical College of Western Reserve University; Visiting Surgeon to St. Vincent's Charity Hospital; Consulting Surgeon to Cleveland City and Lutheran Hospitals.

†1885. Carmalt, William H., A.M., M.D., 261 St. Ronan Street, New Haven, Conn. Emeritus Professor of Surgery in Yale University; Consulting Surgeon to the New Haven Hospital. *President*, 1907; *Vice-President*, 1895; *Member of Council*, 1908.

1909. Carrel, Alexis, L.B., Sc.B., M.D., Rockefeller Institute for Medical Research, Sixty-sixth Street and Avenue A, New York, N. Y.

1896. Carson, Norman Bruce, M.D., 303 Humboldt Bldg., St. Louis, Mo. Professor of Clinical Surgery in the St. Louis

ELECTED

Medical College; Surgeon to St. Louis and Mullanphy Hospitals and to the St. Vincent Insane Asylum, etc. *Vice-President*, 1903.

1910. Codman, Ernest Amory, A.B., M.D., 15 Pinckney Street, Boston, Mass.

†1896. Cole, Charles Knox, A.M., M.D., Helena, Montana. Surgeon to St. John's, St. Peter's, and County Hospitals.

1898. Coley, William B., M.D., 40 East Forty-first Street, New York. Attending Surgeon to the General Memorial Hospital; Associate Surgeon to the Hospital for Ruptured and Crippled, New York.

1914. Cotton, Frederick J., A.B., M.D., A.M., 520 Commonwealth Avenue, Boston, Mass. Assistant Visiting Surgeon, The Boston City Hospital; Instructor in Surgery, Harvard School for Graduate Instruction in Medicine.

1905. Crile, George W., M.D., 1021 Prospect Avenue, Cleveland, Ohio. Professor of Surgery, School of Medicine, Western Reserve University; Visiting Surgeon to Lakeside Hospital.

1906. Cushing, Harvey, A.M., M.D., The Peter Bent Brigham Hospital, Boston. Professor of Surgery, Harvard University.

†1896. Cushing, Hayward Warren, A.B., M.D., 70 Commonwealth Avenue, Boston, Mass. Junior Visiting Surgeon, Boston City Hospital; Assistant Surgeon, Children's Hospital, Boston.

1897. Da Costa, John Chalmers, M.D., 2045 Walnut Street, Philadelphia. Professor of Surgery, Jefferson Medical College; Surgeon to the Philadelphia and the Phœnixville Hospitals.

1917. Darrach, William, A.B., M.A., M.D., 47 West Fiftieth Street, New York City. Professor of Clinical Surgery, College of Physicians and Surgeons; Surgical Director of First Division, Bellevue Hospital; Consulting Surgeon, Memorial Hospital, Morristown, N. J.

1916. Davis, Carl B., A.B., M.D., 122 South Michigan Boulevard, Chicago, Ill. Assistant Professor of Surgery, Rush Medical College; Associate Surgeon, Presbyterian Hospital, Chicago.

1909. Davis, Gwilym G., M.D., M.R.C.S. (Eng.), 1814 Spruce Street, Philadelphia. Associate Professor of Applied Anatomy, University of Pennsylvania; Surgeon to the Episcopal Hospital; Surgeon to St. Joseph's Hospital; Surgeon to the Orthopædic Hospital and Infirmary for Nervous Diseases; Orthopedic Surgeon, Philadelphia General Hospital.

ELECTED

1917. Davis, John Staige, Ph.B., M.D., F.A.C.S., 1200 Cathedral Street, Baltimore, Md. Instructor in Clinical Surgery, Johns Hopkins University; Visiting Surgeon, Union Protestant Infirmary, Hospital for the Women of Maryland, Children's Hospital School; Assistant Visiting Surgeon and Dispensary Surgeon, Johns Hopkins Hospital.

1892. Deaver, John B., M.D., 1634 Walnut Street, Philadelphia. Surgeon-in-Chief to the Lankenau Hospital, Philadelphia.

1912. Deaver, Harry C., M.D., 1701 Spruce Street, Philadelphia. Professor of Surgery, Woman's Medical College of Pennsylvania; Surgeon-in-Chief to Kensington Hospital for Women; Surgeon to the Episcopal Hospital and to the Children's Hospital of the Mary Drexel Home.

1910. Delatour, H. Beeckman, M.D., 73 Eighth Avenue, Brooklyn, N. Y. Clinical Professor of Surgery, Long Island College Hospital; Attending Surgeon, St. John's and Norwegian Hospitals; Surgeon-in-Chief, Jewish Hospital; Consulting Surgeon, Kingston Avenue Hospital, Brooklyn, St. Mary's Hospital, Jamaica, and Hempstead Hospital.

†1882. Dennis, Frederic Shepard, M.D., F.R.C.S. (Eng.), 62 East Fifty-fifth Street, New York. Professor of Clinical Surgery, Cornell University, New York City; Visiting Surgeon to the Bellevue and St. Vincent's Hospitals; Consulting Surgeon to St. Joseph's Hospital, Yonkers, and Montefiore Home, New York City. *President*, 1894; *Vice-President*, 1887; *Member of Council*, 1889.

1910. Dowd, Charles N., A.M., M.D., 127 West Seventy-second Street, New York, N. Y. Professor of Clinical Surgery, Columbia University; Attending Surgeon, Roosevelt Hospital; Consulting Surgeon, General Memorial Hospital, and St. Mary's Free Hospital for Children, New York.

1914. Downes, William A., M.D., 37 West 71st Street, New York, N. Y. Assistant Professor of Clinical Surgery, Cornell Medical School; Attending Surgeon, St. Francis' Hospital; Associate Attending Surgeon to the New York, The Babies', and the Hospital for Ruptured and Crippled; Assistant Surgeon to the General Memorial Hospital.

1901. Eliot, Ellsworth, Jr., M.D., 34 East Sixty-seventh Street, New York. Clinical Lecturer and Demonstrator of Surgery, College of Physicians and Surgeons, New York; Surgeon to the Presbyterian Hospital.

ELECTED

†1893. Elliot, John Wheelock, A.M., M.D. (Harvard), 124 Beacon Street, Boston. Surgeon to Massachusetts General Hospital.

1911. Elting, Arthur W., A.B., M.D., 119 Washington Avenue, Albany, N. Y. Professor of Surgery in the Albany Medical College; Surgeon-in-Chief, St. Peter's Hospital, and Child's Hospital; Attendiug Surgeon to the Albany Hospital.

†1896. Estes, William Lawrence, A.M., M.D., South Bethlehem, Pa. Director and Surgeon-in-Chief of St. Luke's Hospital, Lecturer on Hygiene at Lehigh University.

1898. Eve, Duncan, A.M., M.D., 700 Church Street, Nashville, Tenn. Professor of Surgery and Clinical Surgery, Medical Department, Vanderbilt University; Surgeon to the Nashville City Hospital.

1899. Finney, John M. T., M.D., 1300 Eutaw Place, Baltimore, Md. Associate Professor of Surgery, Johns Hopkins University.

1915. Flint, Joseph Marshall, B.S., M.A., M.D., 320 Temple Street, New Haven, Conn. Professor of Surgery at Yale University.

1904. Frazier, Charles Harrison, M.D., 1724 Spruce Street, Philadelphia, Pa. Professor of Clinical Surgery, University of Pennsylvania; Surgeon to the University Hospital.

1898. Freeman, Leonard, B.S., M.D., 424 Metropolitan Building, Denver, Col. Professor of Surgery, Medical Department, University of Colorado; Surgeon to Denver City and County, St. Joseph's, and National Jewish Hospitals; Consulting Surgeon, Children's and Mercy Hospitals, Denver, Col. *Vice-President*, 1908.

1910. Gage, Homer, A.M., M.D., 72 Pearl Street, Worcester, Mass. Surgeon to Worcester City Hospital and to Memorial Hospital; Consulting Surgeon to St. Vincent's Hospital.

†1882. Gay, George Washington, A.M., M.D., 665 Boylston Street, Boston, Mass. Senior Surgeon to the Boston City Hospital, Clinical Instructor in Surgery in Harvard University. *Member of Council*, 1882.

†1892. Gerrish, Frederic Henry, A.M., M.D. (Bowdoin), LL.D. (University of Michigan and Bowdoin), 675 Congress Street, Portland, Maine. Professor Emeritus of Surgery in the Bowdoin Medical School; Consulting Surgeon to the Maine General Hospital.

†1890. Gerster, Arpad G., M.D., Chir.D., 34 East Seventy-fifth Street, New York. Professor of Surgery in the New York

ELECTED

Polyclinic; Surgeon to the German and Mount Sinai Hospitals. *Vice-President*, 1908; *President*, 1911.

1906. GIBBON, JOHN H., M.D., *Secretary*, 1608 Spruce Street, Philadelphia. Professor of Surgery, Jefferson Medical College; Surgeon to the Pennsylvania Hospital and the Bryn Mawr Hospital.

1906. GIBSON, C. L., M.D., 72 East Fifty-fourth Street, New York, N. Y. Professor of Surgery, Cornell University Medical College; Attending Surgeon to the First Surgical (Cornell Medical) Division of the New York Hospital; Consulting Surgeon to St. Luke's, City, and General Memorial Hospitals. *Vice-President*, 1915.

1911. GREENOUGH, ROBERT B., A.B. (Harvard), M.D. (Harvard), 377 Beacon Street, Boston, Mass. Assistant Professor of Surgery, Harvard Medical School; Assistant Visiting Surgeon, Massachusetts General Hospital.

1916. HAGGARD, WILLIAM D., M.D., F.A.C.S., 706 Church Street, Nashville, Tenn. Professor of Surgery, Vanderbilt University; Surgeon to St. Thomas' Hospital; Visiting Surgeon to Vanderbilt Hospital and Nashville City Hospital.

1909. HALSTEAD, ALBERT E., M.D., 31 North State Street, Chicago, Ill. Professor of Surgery, Northwestern University Medical School; Attending Surgeon to the St. Luke's and Cook County Hospitals; Consulting Surgeon to the Illinois Charitable Eye and Ear Infirmary; Lieut., Medical Reserve Corps, U. S. Army.

†1892. HALSTED, WILLIAM STEWART, B.A., M.D., 1201 Eutaw Place, Baltimore, Md. Surgeon to Johns Hopkins Hospital. *Vice-President*, 1913.

1909. HAMANN, CARL A., M.D., 404 Osborn Bldg., Cleveland, Ohio. Professor of Anatomy, Western Reserve University; Visiting Surgeon to Charity and City Hospitals.

1900. HARRIS, MALCOLM L., M.D., 100 State Street, Chicago, Ill. Professor of Surgery, Chicago Polyclinic; Attending Surgeon, Alexian Brothers' Hospital, St. Luke's Hospital, and Maurice Porter Hospital for Children.

1895. HARTE, RICHARD H., M.D., 1503 Spruce Street, Philadelphia. Associate Professor of Surgery, University of Pennsylvania; Surgeon to the Pennsylvania Hospital, and Orthopædic Hospital and Infirmary for Nervous Diseases; Consulting Surgeon to St. Mary's, St. Timothy's, and Bryn Mawr Hospitals. *President*, 1910.

ELECTED

1916. Hartwell, John A., Ph.B., M.D., 27 East Sixty-third Street, New York. Assistant Professor of Surgery and Professor of Clinical Surgery, Cornell University Medical College; Director of Surgery, Cornell University Division, Bellevue Hospital; Consulting Surgeon to Lincoln Hospital, Lawrence Hospital, Bronxville, N. Y., and United Hospital, Port Chester, N. Y.

1918. Hodge, Edward Blanchard, A.B., M.D., 346 South 16th St., Philadelphia, Pa. Surgeon to Presbyterian and Children's Hospitals; Out-patient Surgeon to Pennsylvania Hospital; Associate Surgeon to Widener Memorial School.

1909. Hotchkiss, Lucius Wales, A.B., M.D., 59 West Forty-eighth Street, New York. Adjunct Professor of Clinical Surgery, Columbia University; Attending Surgeon to Bellevue Hospital; Junior Surgeon to Roosevelt Hospital; Consulting Surgeon to J. Hood Wright Hospital, New York City.

1918. Hubbard, Joshua C., M.D., 86 Bay State Road, Boston, Mass. Assistant in Surgery, Harvard Medical School; Assistant Visiting Surgeon, Boston City Hospital.

†1901. Huntington, Thomas W., A.B., M.D., LL.D., 960 Mills Building, San Francisco, California. Professor of Clinical and Operative Surgery (Emeritus), College of Medicine, University of California; Consulting Surgeon, St. Luke's Hospital, San Francisco. *Vice-President*, 1906; *President*, 1917.

1909. Hutchinson, James P., M.D., 133 South Twenty-second Street, Philadelphia. Surgeon to the Pennsylvania, Methodist, Children's, St. Timothy's and Bryn Mawr Hospitals.

1913. Hutchison, James Alexander, M.D., L.R.C.P. and S. (Edin.), 354 MacKay Street, Montreal. Professor of Surgery and Clinical Surgery, McGill University; Attending Surgeon, Montreal General Hospital.

1913. Jackson, Jabez N., A.M., M.D., 425 Argyle Building, Kansas City, Mo.

1901. Johnson, Alexander B., M.D., 12 East Fifty-eighth Street, New York. Professor of Clinical Surgery, Cornell University Medical College; Attending Surgeon to New York Hospital.

1905. Johnson, Robert W., A.B., M.D., 101 W. Franklin Street, Baltimore, Md. Professor of Principles and Practice of Surgery, Baltimore Medical College; Surgeon to Maryland

ELECTED

General Hospital, Church Home and Infirmary, and St. Agnes' Hospital.

1901. JONAS, A. F., M.D., 454 Brandeis Building, Omaha, Nebraska. Professor of Surgery, Omaha Medical College; Surgeon to the Methodist Episcopal Hospital and to the Douglas County Hospital. *Vice-President*, 1906.

1917. JONES, DANIEL FISKE, A.B., M.D., 195 Beacon Street, Boston, Mass. Associate in Surgery, Harvard Medical School; Visiting Surgeon, Massachusetts General Hospital; Consulting Surgeon to the New England Hospital for Women and Children, Brockton City Hospital, Union Hospital of Fall River, Sturdy Hospital of Attleboro, and the Addison Gilbert Hospital of Gloucester, Mass.

1910. JOPSON, JOHN HOWARD, M.D., 1824 Pine Street, Philadelphia, Pa. Professor of Surgery, Philadelphia Polyclinic; Associate in Surgery, University of Pennsylvania; Surgeon to Presbyterian Hospital, Children's Hospital, and Bryn Mawr Hospital.

1914. JUDD, EDWARD STARR, M.D., Rochester, Minn., Surgeon to St. Mary's Hospital.

1899. KAMMERER, FREDERIC, M.D., 51 East Sixty-sixth Street, New York City. Professor of Clinical Surgery, Cornell Medical College; Surgeon to the German and St. Francis' Hospitals, New York.

1913. KANAVEL, ALLEN B., A.B., M.D., 30 North Michigan Avenue, Chicago, Ill. Assistant Professor of Surgery, Northwestern University Medical School; Attending Surgeon to Wesley and Cook County Hospitals.

*†1880. KEEN, WILLIAM WILLIAMS, A.M., M.D., LL.D., Hon. F.R.C.S. (Eng. and Edin.), 1729 Chestnut Street, Philadelphia. Emeritus Professor of the Principles of Surgery and of Clinical Surgery in the Jefferson Medical College; Surgeon to the Jefferson Medical College Hospital; Consulting Surgeon to the Woman's and St. Agnes' Hospitals; Membre Correspondant Etranger de la Société de Chirurgie de Paris; Membre Honoraire de la Société Belge de Chirurgie; Honorary Member, Clinical Society of London. *President*, 1898; *Vice-President*, 1892; *Member of Council*, 1899–1901.

ELECTED

1910. Law, Arthur Ayer, M.D., F.A.C.S., 420 Syndicate Building, Minneapolis, Minn. Associate Professor of Surgery, University of Minnesota Medical School, and Mayo Foundation; Surgeon to the Northwestern Hospital; Surgeon to and Assistant Chief of the University Hospital.

1901. Le Conte, Robert G., A.B., M.D., 1530 Locust Street, Philadelphia. Surgeon to the Pennsylvania and the Bryn Mawr Hospitals; Consulting Surgeon to the Germantown and the Gynecean Hospitals. *President*, 1915.

1912. Lewis, Dean D., M.D., 122 S. Michigan Ave., Chicago, Ill. Assistant Professor of Surgery, Rush Medical College; Attending Surgeon to the Presbyterian Hospital, Chicago.

1910. Lilienthal, Howard, A.B., M.D., 780 Madison Avenue, New York, N. Y. Attending Surgeon, Mount Sinai Hospital; Visiting Surgeon to Bellevue Hospital; Consulting Surgeon, Hospital for Joint Diseases, Jewish Maternity Hospital, and Har Moriah Hospital.

1908. Lothrop, Howard Augustus, A.M., M.D., 101 Beacon Street, Boston, Mass. Assistant Visiting Surgeon, Boston City Hospital; Instructor in Surgery, Harvard Medical School.

1916. Lower, William E., M.D., 1021 Prospect Avenue, Cleveland, Ohio. Associate Professor of Genito-urinary Surgery, School of Medicine, Western Reserve University; Director of Surgery, Mount Sinai Hospital; Associate Surgeon in charge of Genito-urinary Surgery, Lakeside Hospital; Surgeon, Lutheran Hospital; Surgeon, White Hospital (Ravenna).

1910. Lund, Frederick Bates, M.D., 527 Beacon Street, Boston, Mass. Lecturer on Surgery, Harvard Medical School; Visiting Surgeon, Boston City Hospital.

1917. Lyle, Henry H. M., M.D., 50 East Fifty-third Street, New York City. Professor of Clinical Surgery, College of Physicians and Surgeons, Columbia University; Attending Surgeon, St. Luke's Hospital.

1901. McArthur, L. L., M.D., 122 S. Michigan Boulevard, Chicago, Ill. Professor of Clinical Surgery, Post-Graduate Medical School; Assistant Professor of Clinical Surgery, Rush Medical College; Surgeon to St. Luke's and Michael Reese Hospitals.

1882. McGraw, Theodore A., M.D., 73 Case Street, Detroit, Mich. Professor of Surgery in the Detroit Medical College; Surgeon to St. Mary's and Harper Hospitals. *Vice-President*, 1896.

ELECTED

1917. McGuire, Stuart, M.D., LL.D., 513 East Grace Street, Richmond, Va. Professor of Surgery, Medical College of Virginia; Surgeon in Charge of St. Luke's Hospital; Visiting Surgeon to Memorial Hospital.

1903. McMurtry, Lewis S., A.M., M.D., LL.D., 542 Atherton Building, Louisville, Ky. Professor of Gynecology and Abdominal Surgery in the Medical Department, University of Louisville; Surgeon to the Louisville City Hospital.

1915. McRae, Floyd W., M.D., Peters Building, Atlanta, Ga. Chief Surgeon to the Piedmont Sanatorium; Visiting Surgeon to St. Joseph's Infirmary; Consulting Surgeon to Grady Hospital.

1918. McWilliams, Clarence A., B.A., M.D., 33 East 63d St., New York, N. Y. Associate Surgeon, Presbyterian Hospital.

1908. Mackenzie, Kenneth A. J., M.D., L.R.C.P., and L.R.C.S. (Edin.), 908 Corbett Building, Portland, Oregon. Professor of Operative Surgery, Medical Department, Oregon State University; Surgeon to St. Vincent's Hospital, Portland, Oregon.

1904. MacLaren, Archibald, M.D., B.S., 914 Lowry Building, St. Paul, Minn. Professor of Clinical Surgery, University of Minnesota. *Vice-President*, 1915.

1914. MacLaren, Murray, B.A., M.B.C.M., M.D., M.R.C.S. (Eng.), 75 Coburg Street, St. John's, N. B., Canada. Surgeon to the General Public Hospital.

1898. Martin, Edward, M.D., 1506 Locust Street, Philadelphia. Clinical Professor of Surgery, University of Pennsylvania and Woman's Medical College of Pennsylvania, Philadelphia; Surgeon to Philadelphia, St. Agnes', and Howard Hospitals.

1915. Martin, Walton, Ph.B., M.D., 151 East Sixty-third Street, New York. Professor of Clinical Surgery, Columbia University; Attending Surgeon, St. Luke's Hospital; Consulting Surgeon, White Plains Hospital and Loomis Sanatorium.

†1895. Mastin, William McDowell, M.D., LL.D., Northeast corner of Joachim and Conti Streets, Mobile, Ala. Surgeon to the Mobile City Hospital.

1895. Matas, Rudolph, M.D., 2255 St. Charles Avenue, New Orleans, La. Professor of Surgery, Medical Department, Tulane University; Professor of Clinical Surgery, New Orleans Polyclinic; Surgeon to Charity Hospital; Consulting Surgeon to the Eye, Ear, Nose, and Throat Hospital. *President*, 1909; *Vice-President*, 1901.

ELECTED

1918. Mathews, Francis Stuart, B.S., M.D., 62 West 50th St,. New York, N. Y. Assistant Professor of Clinical Surgery, Columbia University; Surgeon to St. Luke's Hospital and St. Mary's Hospital for Children.

1903. Mayo, Charles, H., A.M., M.D., LL.D., Rochester, Minn. Surgeon to St. Mary's Hospital.

1899. Mayo, William J., A.M., M.D., D.Sc., F.R.C.S. (Edin.), LL.D. (Tor.), 427 West College Street, Rochester, Minn. Surgeon to St. Mary's Hospital. *Vice-President*, 1903; *President*, 1913.

*†1880. Mears, James Ewing, A.M., M.D., LL.D., 1535 Land Title Building, Philadelphia. *President*, 1893; *Recorder*, 1881–93.

1901. Meyer, Willy, M.D., 700 Madison Avenue, New York. Professor of Surgery in the New York Post-Graduate Medical School and Hospital; Attending Surgeon to the German and New York Skin and Cancer Hospitals; Consulting Surgeon to the New York Infirmary for Women and Children.

1917. Mitchell, Charles F., M.D., 252 South Sixteenth Street, Philadelphia, Pa. Attending Surgeon to the Germantown and Bryn Mawr Hospitals; Out-Patient Surgeon to the Pennsylvania Hospital.

1912. Mitchell, James F., A.B., M.D., 1344 Nineteenth Street, Washington, D. C. Surgeon to Providence Hospital.

1893. Mixter, Samuel Jason, S.B. (Massachusetts Institute of Technology), M.D. (Harvard), 180 Marlborough Street, Boston. Surgeon to Carney Hospital; Consulting Surgeon to Massachusetts General Hospital and to Massachusetts Charity Eye and Ear Infirmary; Instructor in Surgery, Harvard University.

†1896. Monks, George Howard, A.B. (Harvard), M.D. (Harvard), M.R.C.S. (Eng.), 51 Commonwealth Ave., Boston. Junior Visiting Surgeon, Boston City Hospital; Lecturer on Surgery, Harvard Medical School and Harvard Dental School.

†1895. Moore, James E., M.D., 616 Syndicate Bldg., Minneapolis, Minn. Professor of Surgery, University of Minnesota; Surgeon-in-Chief to the Northwestern Hospital. *Vice-President*, 1905.

1914. Moschcowitz, Alexis V., M.D., 925 Madison Ave., New York, N. Y. Associate Surgeon, Mt. Sinai Hospital, Attending Surgeon, Hor Moriah Hospital.

ELECTED

1904. Mudd, Harvey G., M.D., Humboldt Building, St. Louis, Mo. Professor of Fractures and Dislocations and Clinical Surgery, Medical Department, Washington University; Surgeon to St. Luke's Hospital; Consulting Surgeon to the St. Louis City Hospital.

1913. Murphy, Fred T., A.B., M.D., Washington University Medical School, St. Louis, Mo. Professor of Surgery, Washington University Medical School; Surgeon-in-Chief, Washington University Hospital and St. Louis Children's Hospital.

†1898. Murray, Francis W., M.D., 32 West Thirty-ninth Street, New York City. Professor of Clinical Surgery in Cornell University Medical College; Surgeon to the New York and St. Luke's Hospitals.

†1882. de Nancrède, C. B. G., A.M. (University of Pennsylvania), M.D., LL.D. (Jefferson), 504 South State Street, Ann Arbor, Mich. Professor of Surgery in the University of Michigan; Professor of Surgery, Dartmouth Medical College. *President*, 1908; *Vice-President*, 1889 and 1899.

1903. Neilson, Thomas R., M.D., 1937 Chestnut Street, Philadelphia, Pa. Surgeon to the Episcopal Hospital and to St. Christopher's Hospital for Children; Clinical Professor of Genito-urinary Diseases in the University of Pennsylvania.

1915. Nichols, Edward Hall, A.B., A.M., M.D., 204 Marlborough Street, Boston, Massachusetts. Associate Professor of Surgery, Harvard University Medical School; Senior Visiting Surgeon, Boston City Hospital; Consulting Surgeon, City Hospital, Quincy, and Framingham Hospital, Framingham.

1900. Ochsner, A. J., B.S., F.R.M.S., M.D. (Eng.), 710 Sedgwick Street, Chicago. Professor of Clinical Surgery, College of Physicians and Surgeons; Surgeon-in-Chief of Augustana and St. Mary's Hospitals.

1900. Oliver, J. C., M.D., 628 Elm Street, Cincinnati, Ohio. Dean and Professor of Operative Surgery, Miami Medical College; Surgeon to Cincinnati, Presbyterian, and Christ Hospitals.

1915. Olmsted, Ingersoll, M.B., 215 James Street, South, Hamilton, Ontario. Surgeon to City Hospital.

ELECTED

†1882. Owens, John E., M.D., 1017–18 Venetian Building, Chicago, Ill. Professor of Principles and Practice of Surgery and Clinical Surgery in the Chicago Medical College; Surgeon to St. Luke's Hospital. *Vice-President*, 1900.

1890. Parham, Frederick William, M.D., 741 Carondelet Street, New Orleans, La. Professor of General, Clinical, and Operative Surgery on the Cadaver, New Orleans Polyclinic; Surgeon to Charity Hospital; Consulting Surgeon to Eye, Ear, Nose, and Throat Hospital.

†1893. Parmenter, John, M.D., 519 Franklin Street, Buffalo, N. Y. Professor of Anatomy and Clinical Surgery in the Medical Department of the University of Buffalo; Surgeon to the Sisters of Charity, Erie County, Fitch, Children's, and Emergency Hospitals; Assistant Surgeon to the Buffalo General Hospital.

1908. Peck, Charles Howard, M.D., *Treasurer*, 30 West Fiftieth Street, New York City. Associate in Surgery, Columbia University; Attending Surgeon to French Hospital; Junior Attending Surgeon to Roosevelt Hospital.

1917. Phemister, Dallas B., B.S., M.D., 122 South Michigan Avenue, Chicago, Ill. Instructor in Surgery, Rush Medical College; Associate Attending Surgeon, Presbyterian Hospital.

†1889. Pilcher, Lewis S., A.M., M.D., LL.D. (Dickinson), 145 Gates Avenue, Brooklyn, N.Y. Professor of Clinical Surgery in the Post-Graduate Medical School, New York; Surgeon to the Methodist Episcopal Hospital, New York. *Vice-President*, 1893. *President*, 1918.

1914. Plummer, Samuel C., A.B., M.D., 4539 Oakenwald Avenue, Chicago, Ill. Attending Surgeon, St. Luke's Hospital; Clinical Professor of Surgery, Northwestern University Medical School; Chief Surgeon, C. R. I. & P. Ry. Co.

1914. Pool, Eugene Hillhouse, A.B., M.D., 107 East 60th Street, New York, N. Y. Attending Surgeon, French Hospital; Associate Attending Surgeon, New York Hospital; Instructor of Surgery, Columbia University; Consultant Surgeon to New York Orthopædic and Manhattan State Hospitals, and Home for Incurables.

1904. Porter, Charles Allen, A.M., M.D., 245 Beacon Street, Boston, Mass. Assistant Surgeon to the Massachusetts General Hospital; Instructor in Surgery, Harvard Medical School.

ELECTED

1915. PORTER, MILES FULLER, M.A., M.D., 207 West Wayne Street, Fort Wayne, Ind. Professor of Surgery in the Indiana University School of Medicine; Surgeon-in-Chief to Hope Hospital; Consulting Surgeon in the Indiana School for Feeble-minded Youths.

†1896. POWERS, CHARLES A., A.M., M.D., Metropolitan Building, Denver, Col. Professor of Clinical Surgery, Emeritus, in the University of Colorado, and Surgeon to St. Luke's Hospital and to the Children's Hospital; Consulting Surgeon to the Denver City and County Hospital, to the Mercy Hospital, and to the State Home for Children. *President*, 1912; *Vice-President*, 1903; *Treasurer*, 1906–1912; *Member of Council*, 1906–1916.

1908. PRIMROSE, ALEXANDER, M.B., C.M. (Edin.), M.R.C.S. (Eng.), 100 College Street, Toronto, Canada. Surgeon to the Toronto General Hospital and to the Hospital for Sick Children, Toronto; Associate Professor of Clinical Surgery in the University of Toronto.

1886. RANSOHOFF, JOSEPH, M.D., F.R.C.S. (Eng.), 19 West Seventh Street, Cincinnati, Ohio. Professor of Anatomy in the Medical College of Ohio; Surgeon to the Cincinnati and the Good Samaritan Hospitals. *Vice-President*, 1911.

1901. RIXFORD, EMMET, B.S., M.D., 1795 California Street, San Francisco, Cal. Professor of Surgery in Cooper Medical College; Surgeon to City, County, and Lane Hospitals. *Vice-President*, 1905.

†1882. ROBERTS, JOHN B., A.M., M.D., 313 South Seventeenth Street, Philadelphia. Professor of Anatomy and Surgery in the Philadelphia Polyclinic; Surgeon to the Methodist and Jewish Hospitals. *Vice-President*, 1888 and 1894; *Treasurer*, 1892–93.

1914. ROSS, GEORGE GORGAS, M.D., 1721 Spruce Street, Philadelphia, Pa. Visiting Surgeon, Germantown Hospital; Assistant Surgeon, Lankenau Hospital.

1917. ROWAN, CHARLES J., A.B., M.D., Iowa City, Iowa. Professor and Head of Department of Surgery, College of Medicine, State University of Iowa; Director of the University Hospital.

†1882. RUSHMORE, JOHN DIKEMAN, M.D., 129 Montague Street, Brooklyn, N. Y. Professor of Surgery in the Long Island College Hospital; Surgeon to the Brooklyn, St. Peter's, and the Eye and Ear Hospitals.

ELECTED

1900. SCUDDER, CHARLES L., M.D., A.B., Ph.B., 209 Beacon Street, Boston, Mass. Assistant Professor of Surgery, Harvard Medical School; Chief of the East Surgical Service, Massachusetts General Hospital.

†1902. SHEPHERD, FRANCIS J., M.D., 152 Mansfield Street, Montreal, Canada. Professor of Anatomy and Lecturer on Operative Surgery in McGill University, Montreal; Senior Surgeon to the Montreal General Hospital.

1905. SHERMAN, HARRY M., A.B., M.D., A.M., 350 Post Street, San Francisco, Cal. Professor of Surgery in the University of California; Surgeon to St. Luke's Hospital, San Francisco; Orthopedic Surgeon to the Children's Hospital, San Francisco.

1918. SMITH, REA, M.D., 22 Chester Place, Los Angeles, Cal. Surgeon, Los Angeles Hospital and Los Angeles County Hospital; Consulting Surgeon, San Pedro, Los Angeles and Salt Lake R. R.

†1895. SOUCHON, EDMOND, M.D., 2403 St. Charles Avenue, New Orleans, La. Professor of Anatomy and of Clinical Surgery, Tulane University; Surgeon to Charity Hospital; Consulting Surgeon to the Eye, Ear, Nose, and Throat Hospital. *Vice-President*, 1899.

1918. STARR, CLARENCE LESLIE, M.B., M.D., 224 Bloor St., West, Toronto, Canada. Associate Professor of Surgery, University of Toronto; Surgeon-in-Chief, Hospital for Sick Children; Consultant in Surgery, Toronto General Hospital; Surgeon to St. John's Hospital.

1914. STARR, FREDERIC NEWTON GISBORNE, M.B., M.D.C.M., 112 College Street, Toronto, Canada. Associate Professor of Clinical Surgery, University of Toronto; Surgeon to Hospital for Sick Children, and to St. John's Hospital for Women; Senior Assistant Surgeon, Toronto General Hospital.

1911. STEWART, FRANCIS T., M.D., 311 S. 12th Street, Philadelphia, Pa. Professor of Clinical Surgery, Jefferson Medical College; Surgeon to Germantown Hospital; Out-patient Surgeon, Pennsylvania Hospital.

1915. STEWART, GEORGE DAVID, M.D., 61 West Fiftieth Street, New York. Professor of Surgery, New York University Medical School; Visiting Surgeon to St. Vincent's and Bellevue Hospitals; Consulting Surgeon to Hospital for Ruptured and Crippled of New York, to St. Joseph's

ELECTED

Hospital, Yonkers, to St. Mary's Hospital, East Orange, N. J., to South Side Hospital, Babylon, L. I., and to Englewood Hospital, Englewood, N. J.

1909. STILLMAN, STANLEY, M.D., 2101 Webster Street, San Francisco, Cal. Professor of Surgery, Cooper Medical College; Surgeon to Lane Hospital and City and County Hospital.

1912. STOKES, CHARLES F., A.M., M.D., D.Sc., LL.D., Washington, D. C. Surgeon-General, United States Navy.

1909. SUMMERS, JOHN EDWARD, M.D., 618 Brandeis Theatre Bldg., Omaha, Neb. Surgeon to the Clarkson Memorial, the Wise Memorial, and the Douglass County Hospitals, Omaha, Neb.

1900. TAYLOR, WILLIAM J., M.D., 1825 Pine Street, Philadelphia. Surgeon to the Orthopædic Hospital and Infirmary for Nervous Diseases, and to St. Agnes' Hospital; Consulting Surgeon to the West Philadelphia Hospital for Women.

1916. TERRY, WALLACE I., B.S., M.D., 240 Stockton Street, San Francisco, Cal. Professor of Surgery, University of California; Chief Surgeon, University of California Hospital, San Francisco.

1909. THOMPSON, JAMES E., M.B., B.S., Lond., F.R.C.S., Eng., 3224 Broadway, Galveston, Texas. Professor of Surgery in the University of Texas Medical School; Surgeon to the John Sealy Hospital.

1918. TRUESDALE, PHILEMON EDWARDS, M.D., 177 Winter St., Fall River, Mass. Surgeon to St. Anne's and Highland Hospitals; Consulting Surgeon to Fall River City Hospital.

†1882. VANDER VEER, ALBERT, A.M., M.D., Ph.D., LL.D., 28 Eagle St., Albany, N. Y. Professor of Surgery, Albany Medical College; Surgeon-in-Chief, Albany Hospital; Consulting Surgeon, Albany Free Dispensary Association; Consulting Surgeon, Benedictine Hospital, Kingston, N. Y., and Champlain Valley Hospital, Plattsburgh, N. Y.; *President*, 1905; *Vice-President*, 1898; *Member of Council*, 1907.

1910. VANDER VEER, EDGAR ALBERT, Ph.B., M.D., 28 Eagle Street, Albany, N. Y. Clinical Professor of Surgery, Albany Medical College; Attending Surgeon, Albany Hospital; Consulting Surgeon, Champlain Valley Hospital.

ELECTED

1902. VAUGHAN, GEORGE TULLY, M.D., 1718 I Street, Washington, D. C. Professor of Principles and Practice of Surgery, Georgetown University; Professor of Surgery and Genito-urinary Surgery, Washington Post-Graduate Medical School; Chief Surgeon, Georgetown University Hospital; Surgeon, Emergency Hospital; Consulting Surgeon, Government Hospital for the Insane, Washington, D. C.; Assistant Surgeon-General, U. S. Public Health and Marine Hospital Service.

1918. WAINWRIGHT, JONATHAN M., A.B., A.M., M.D., 912 Clay Ave., Scranton, Pa. Surgeon-in-Chief, Moses Taylor Hospitals (Scranton and Buffalo); Chief Surgeon, D. L. & W. R. R. Co.

1891. WALKER, EDWARD W., M.D., 30 Garfield Place, Cincinnati, Ohio. Professor of Surgery, Miami Medical College.

1909. WALKER, JOHN B., M.D., 50 E. Thirty-fourth St., New York, N. Y. Surgeon to the Bellevue Hospital; Assistant Surgeon to the Hospital for Ruptured and Crippled, New York.

†1882. WARREN, JOHN COLLINS, M.D., LL.D. (Jefferson), Hon. F.R.C.S. (Eng.), 58 Beacon Street, Boston, Mass. Professor of Surgery in Harvard University; Surgeon to the Massachusetts General Hospital. *President*, 1896; *Vice-President*, 1890; *Member of Council*, 1897.

†1896. WATSON, FRANCIS SEDGWICK, A.B., M.D., 92 Marlborough St., Boston. Surgeon to the Boston City Hospital; Instructor in Genito-Urinary Surgery, Harvard Medical School.

1913. WATTS, STEPHEN H., M.A., M.D., Department of Surgery, University of Virginia, Charlottesville, Va. Professor of Surgery and Gynecology in the University of Virginia; Surgeon-in-Chief, University of Virginia Hospital.

†1889. WEIR, ROBERT F., A.M., M.D., Hon. F.R.C.S. (Eng.), Cor. Mem. Surg. Soc., Paris, 1155 Park Avenue, New York. Professor of Surgery in the College of Physicians and Surgeons, Columbia University; Surgeon to the Roosevelt Hospital. *President*, 1899; *Member of Council*, 1893–1896; 1901–03.

†1892. WHARTON, HENRY R., A.M., M.D., 1725 Spruce Street, Philadelphia. Surgeon to the Presbyterian, Children's, and Methodist Hospitals.

1914. WINSLOW, RANDOLPH, A.B., M.D., A.M., LL.D., 1900 Mt. Royal Terrace, Baltimore, Md. Professor of Surgery, University of Maryland; Chief Surgeon, University Hos-

ELECTED

pital; Surgeon, Hebrew Hospital; Consulting Surgeon to Union Hospital, Elkton, Md., and to James L. Kernan Hospital for Crippled Children, Baltimore.

1918. WOOD, ALFRED CONARD, M.D., 2035 Walnut St., Philadelphia, Pa. Assistant Professor of Surgery, University of Pennsylvania; Surgeon to the University, Philadelphia General, Howard, St. Timothy's and Rush Hospitals.

1901. WOOLSEY, GEORGE, M.D., 117 East Thirty-sixth Street, New York City. Professor of Anatomy and Clinical Surgery, Cornell University; Surgeon to Bellevue Hospital; Associate Surgeon to the Presbyterian Hospital.

1916. YATES, J. L., Ph.B., B.S., M.D., F.A.C.S., 141 Wisconsin Street, Milwaukee, Wis. Professor of Clinical Surgery, Marquette University; Chief of Surgical Staff, Milwaukee County Hospital; Consulting Surgeon, Johnson Emergency Hospital.

SENIOR FELLOWS OF THE ASSOCIATION

Abbe, Robert, M.D., 13 West Fiftieth Street, New York.
Allis, Oscar H., M.D., 1604 Spruce Street, Philadelphia, Pa.

Barton, James M., M.D., 32 North New Hampshire Ave., Atlantic City, N. J.
Bradford, E. H., M.D., 133 Newbury Street, Boston, Mass.

Carmalt, William H., M.D., 261 St. Ronan St., New Haven, Conn.
Cole, Charles Knox, A.M., M.D., Helena, Montana.
Cushing, Hayward Warren, A.B., M.D., 70 Commonwealth Ave., Boston, Mass.

Dennis, Frederic Shepard, M.D., F.R.C.S. (Eng.), 62 East 55th Street, New York, N. Y.

Elliott, John Wheelock, A.M., M.D., 124 Beacon Street, Boston, Mass.
Estes, William Lawrence, A.M., M.D., South Bethlehem, Pa.

Gay, George W., 665 Boylston Street, Boston, Mass.
Gerrish, Frederic H., A.M., M.D., LL.D., 675 Congress Street, Portland, Me.
Gerster, Arpad G., M.D., Chir.D., 34 East Seventy-fifth Street, New York, N. Y.

Halsted, Wm. Stewart, M.D., 1201 Eutaw Place, Baltimore, Md.
Huntington, Thomas W., A.B., M.D., LL.D., 960 Mills Building, San Francisco, Cal.

Keen, W. W., A.M., M.D., LL.D., 1729 Chestnut Street, Philadelphia, Pa.

Mastin, Wm. M., M.D., Northeast corner Joachim and Conti Streets, Mobile, Ala.
Mears, James Ewing, A.M., M.D., LL.D., 1535 Land Title Building, Philadelphia, Pa.

Monks, George H., A.B., M.D., M.R.C.S., 51 Commonwealth Avenue, Boston, Mass.

Moore, James E., M.D., 616 Syndicate Building, Minneapolis, Minn.

Murray, Francis W., M.D., 32 West Thirty-ninth Street, New York, N. Y.

de Nancrède, C. B. G., A.M., M.D., LL.D., 504 South State Street, Ann Arbor, Mich.

Owens, John E., M.D., 1201 Venetian Building, Chicago, Ill.

Parmenter, John, M.D., 519 Franklin Street, Buffalo, N. Y.

Pilcher, Lewis S., A.M., M.D., LL.D., 145 Gates Avenue, Brooklyn, New York. President, 1918.

Powers, Charles A., A.M., M.D., Metropolitan Building, Denver, Colo.

Roberts, John B., A.M., M.D., 313 South Seventeenth Street, Philadelphia, Pa.

Rushmore, John D., M.D., 129 Montague Street, Brooklyn, N. Y.

Shepherd, Francis J., M.D., 152 Mansfield Street, Montreal, Canada.

Souchon, Edmund, M.D., 2103 St. Charles Ave., New Orleans, La.

Vander Veer, A., A.M., M.D., Ph.D., LL.D., 28 Eagle Street, Albany, N. Y.

Warren, J. Collins, M.D., 58 Beacon Street, Boston, Mass.

Watson, Francis S., A.B., M.D., 92 Marlborough Street, Boston, Mass.

Weir, Robert F., M.D., 1155 Park Avenue, New York, N. Y.

Wharton, Henry R., A.M., M.D., 1725 Spruce Street, Philadelphia, Pa.

HONORARY FELLOWS OF THE ASSOCIATION

ELECTED

1907. Ballance, Charles Alfred, M.D., M.S., University of London, F.R.C.S. (Eng.), 106 Harley Street, London.

1891. Chiene, John, F.R.C.S. (Edin.), M.D. (Edin.), 26 Charlotte Square, Edinburgh, Scotland. Professor of Surgery in the University of Edinburgh.

1916. Depage, Prof. Dr. Antoine, Le Panne, Belgium.

1911. von Eiselsberg, Freiherr Anton, Vienna, Austria. Professor of Surgery, Vienna University.

1916. Gorgas, William C., Surgeon-General, A.B., M.D., Sc.D., LL.D., War Department, Washington, D. C.

1918. Keogh, Sir Alfred, Ky., K.C.B., Royal Army Medical Corps, England.

1894. Macewen, Sir William, M.D., M.B., M.S., 3 Woodside Crescent, Glasgow, Scotland. Professor of Surgery, The University, Glasgow.

1918. Makins, Sir George, Surgeon General, K.C.M.G., C.B., F.R.C.S., England.

1908. Moynihan, Sir B. G. A., M.S. (Lond.), F.R.C.S., 33 Park Square, Leeds, England. Surgeon to the Leeds Infirmary,

1907. Myles, Sir Thomas, M.D., F.R.C.S.I., 33 Merrion Square. N., Dublin, Ireland.

1907. Pozzi, Professor S., Avenue de Jena, Paris, France. Professor of Surgery, University of Paris.

1903. Robson, A. W. Mayo, C.V.O., M.D., F.R.C.S., D.Sc., 8 Park Crescent, Portland Place, London, W., England. Vice-President, Royal College of Surgeons of England; Hunterian Professor of Surgery and Pathology.

ELECTED

1882. Smith, Stephen, A.M., M.D., LL.D., 574 Madison Avenue, New York. Professor of Clinical Surgery in the University Medical College of New York; Surgeon to the Bellevue and St. Vincent's Hospitals. *Vice-President*, 1890.

1912. Stiles, Harold Jalland, M.B., F.R.C.S. (Edin.), 9 Great Stuart Street, Edinburgh, Scotland. Surgeon to Chalmers Hospital and to the Royal Edinburgh Hospital for Sick Children, Edinburgh.

1914. Thomson, Alexis, B.M., M.S., M.D., (Edin.), M.R.C.S. (Eng.), 39 Drumsheugh Gardens, Edinburgh, Scotland. Professor of Surgery, University of Edinburgh.

1907. Trendelenburg, Prof. Dr. F., Leipzig, Germany. Professor of Surgery, University of Leipzig, Germany.

1918. Tuffier, Th., M.D., 42 Avenue Gabriel, Paris, France.

DECEASED FELLOWS OF THE ASSOCIATION

Name	Date of death
Agnew, D. Hayes	March 22, 1892
Allen, Dudley Peter	January 6, 1915
Annandale, Thomas	1907
Ashhurst, John, Jr.	July 7, 1900
*Atlee, John Light	October 1, 1885
Beckman, Emil Hessel	November 7, 1916
Benham, Silas Nelson	November 3, 1890
*von Bergmann, Ernst	Died since 1906 Meeting
*Bigelow, Henry Jacob	October 30, 1890
*Billings, John Shaw	March 11, 1913
*Billroth, Albert Christian Theodor	January 5, 1894
Bontecou, R. B.	1906–1907
Briggs, William Thompson	June 13, 1894
Brinton, John Hill	March 18, 1908
Bristow, Algernon Thomas	March 26, 1913
Brock, Hugh W.	April 24, 1882
Bryant, Joseph Decatur	April 7, 1914
*Bryant, Thomas	1914–1915
Bull, William Tillinghast	February 22, 1909
Burrell, Herbert Leslie	1910
Byrd, William Andrew	August 14, 1887
Cabot, Arthur Tracy	November 4, 1912
Campbell, Henry Fraser	December 15, 1891
Cheever, David Williams	December 27, 1915
Conner, Phineas Sanborn	March 26, 1909
Cunningham, Francis Deane	September 11, 1885
*Czerny, Prof. Dr. Vincenz	October 3, 1916
Dandridge, Nathaniel P.	1911–1912
Davis, John Staige	July 18, 1885
Dawson, William Wirt	February 16, 1893
Dugas, Louis Alexander	October 19, 1884
Dunn, James Henry	June 16, 1904
Dunott, Thomas Justus	May 20, 1893
*Durham, Arthur Edward	May 7, 1895

* Honorary.

Name	Date of death
*Erichsen, Sir John Eric	September 23, 1896
*von Esmarch, Friedrich	1907
Fenger, Christian	March 7, 1902
Ferguson, Alexander Hugh	October 20, 1911
Forbes, William Smith	December 17, 1905
Fowler, George Ryerson	February 6, 1906
*Friedrich, Paul Leopold	January 5, 1916
Gaston, James McFadden	November 17, 1903
Greene, W. Warren	September 10, 1881
Gross, Samuel David	May 6, 1884
Gross, Samuel Weissel	April 16, 1889
Gunn, Moses	November 4, 1887
*Gussenbauer, Karl	June 19, 1903
Guthrie, George Washington	June 1, 1915
Harrington, Francis B.	1914–1915
*Harrison, Reginald	1907
Hearn, W. Joseph	1917
Hodge, H. Lenox	June 16, 1881
Hodgen, John T.	April 28, 1882
Homans, John	February 7, 1903
*Horsley, Sir Victor Alexander, C. B.	July 16, 1916
Horwitz, Orville	January 28, 1913
*Horwitz, Phineas J.	September 28, 1904
Hughes, J. C.	August 10, 1881
*Humphrey, Sir George Murray	September 24, 1896
*Hunt, William	January 5, 1897
Jacobson, Nathan	September 16, 1913
Johnston, George Ben	1917
Johnston, Christopher	October 11, 1891
King, Alfred	June 4, 1916
Kinloch, Robert Alexander	December 23, 1891
*Kocher, Theodor	1918
Lane, Levi Cooper	February 18, 1902
*von Langenbeck, Bernhardt	September 30, 1887
Levis, Richard J.	November 12, 1890
*Lister, Joseph	February 11, 1912
Little, James Lawrence	April 4, 1885
Lutz, Frank Joseph	March 24, 1916

* Honorary.

Name	Date of death
McCann, James	1893
McCosh, Andrew J.	1908–1909
McGuire, Hunter	September 19, 1900
*MacCormac, Sir William	December 4, 1901
MacDonald, Willis Goss	December 30, 1910
MacMonagle, Beverly	May 22, 1912
Markoe, Francis Hartman	1907
Marks, Solon	1916
Mastin, Claudius Henry	October 3, 1898
Michael, J. Edwin	December 7, 1895
*Mikulicz-Radecki, John V.	
Miles, Albert B.	August 5, 1894
Millard, Perry H.	February 1, 1897
Miller, Truman W.	May 31, 1900
*Moore, Edward Mott	March 3, 1902
Mudd, Henry Hodgen	November 20, 1899
Mumford, James Gregory	October 18, 1914
Murphy, John B.	1915–1916
Norris, Basil E.	October, 1895
*von Nussbaum, J. N.	October 31, 1890
*Ollier, Leopold	1900–1901
Oviatt, Charles W.	October 31, 1912
*Paget, Sir James	December 30, 1899
Pancoast, William H.	January 5, 1897
Park, Roswell	February 15, 1914
*Parker, Willard	April 25, 1884
Parkes, Charles T.	March 28, 1891
Parkhill, Clayton	January 16, 1902
*Péan, Jules E.	January 30, 1898
Peck, Washington F.	December 30, 1891
Pilcher, Paul Monroe	January 4, 1917
Porter, Charles Burnham	May 21, 1909
Porter, William Gibbs	January 30, 1906
Prewitt, Theodore F.	October 17, 1904
Prince, David	December 19, 1889

* Honorary.

Name	Date of death
Reed, Thomas Baird	April 1, 1891
Richardson, Maurice Howe	July 31, 1912
Richardson, Tobias Gibson	May 26, 1892
Rodman, William Louis	March 8, 1915
Sabine, Thomas Taunton	August 23, 1888
Sayre, Lewis A.	1900–1901
*Schede, Max	1902
Senn, Nicholas	January 2, 1908
*Sims, J. Marion	November 13, 1883
Squire, Truman Hoffman	November 27, 1889
*Terrier, Louis Felix	1908
*Thiersch, Karl	April 28, 1895
Thompson, Joseph Ford	February 1, 1917
Thompson, Joseph W.	March 30, 1886
Thomson, William	August 3, 1907
Tiffany, Louis McLane	October 23, 1916
Varick, Theodore Romeyn	November 23, 1887
*Verneuil, Aristide A. S.	June 11, 1895
*von Volkmann, Richard	November 28, 1889
Watson, Beriah Andrew	December 22, 1892
Weeks, Stephen Holmes	September 1, 1909
Weist, Jacob Rowland	May 14, 1900
*Wells, Sir Thomas Spencer	January 31, 1897
White, James William	April 24, 1916
Wight, Jarvis S.	November 16, 1901
Willard, DeForest	October 14, 1910
Wood, James R.	May 4, 1882
*Yandell, David Wendell	May 2, 1898

* Honorary.

REPORT OF COMMITTEE ON NECROLOGY

The Committee on Necrology respectfully reports the deaths during 1916 of Dr. George Ben Johnston, of Richmond, Va., Dr. John B. Murphy, of Chicago, and Dr. Louis McLane Tiffany, of Baltimore; in 1917 Dr. W. Joseph Hearn, of Philadelphia, and in 1918 Professor Dr. Theodor Kocher, of Berne, Switzerland, Honorary Fellow.

Obituary notices of these Fellows will be prepared for the *Transactions*.

All of which is respectfully submitted.

John B. Roberts,
for the Committee.

LOUIS McLANE TIFFANY, M.D.

Dr. Louis McLane Tiffany, who died on October 23, 1916, was born in Baltimore, Maryland, on October 10, 1844. His collegiate education was obtained at the University of Cambridge, England, where he received the degree of B.A. in 1866, and some years thereafter the degree of M.A. was conferred on him by the same institution. He graduated from the medical school of the University of Maryland in 1868. During his pupilage in medicine he was an office student of Nathan R. Smith, and to this fact, doubtless, was largely due his inspiration as well as his aptitude for surgical work.

The year after his graduation he became demonstrator of anatomy in the University of Maryland, in 1874 he was made professor of operative surgery and in 1881 professor of surgery in his alma mater.

He was a surgeon of wide repute and national reputation, and performed many remarkable operations with great success. Among his more important surgical achievements was the temporary depression of both upper jaws for the removal of a large nasopharyngeal polypus in a man, who recovered. He repeated this operation on another individual at a later period, also with success. He performed the first

nephrolithotomy in the United States, removing successfully a large calculus from the kidney. He also achieved special distinction by his operations for the removal of the Gasserian ganglion for inveterate facial neuralgia. He removed successfully the spleen for malarial hypertrophy. His surgical activities were very varied and extensive, and for many years he dominated surgical thought, as well as surgical practice, in his city and State.

While not an orator, his lectures were impressive and instructive to his students, who ever thereafter were able to bear in mind the important lessons he strove to impress upon them.

He contributed many important articles to the various medical journals of the country, and he was held in such high regard that he was elected president of the Southern Surgical and Gynecological Association and of the American Surgical Association in the same year, 1895. In 1902, owing to failing health, he resigned his chair in the University of Maryland and soon thereafter retired from the practice of his profession.

Tall, dignified and handsome, he was a marked man in any company; urbane and polished in manner, he was a delightful companion; keen and satirical in dispute, he was an opponent to be dreaded. With a mind of exceptional acuity and with perseverance and great industry, he solved difficult problems of surgery, developed an almost unerring judgment, and attained an enviable fame as a skilful surgeon.

R. W.

GEORGE BEN JOHNSTON, M.D., LL.D.

Dr. George Ben Johnston was born in Tazewell, Virginia, on July 25, 1853, and died in Richmond, Virginia, on December 20, 1916, at the age of sixty-three years.

He came of distinguished ancestry, his mother, Nicketti Buchanan Floyd, being the daughter of Dr. John Floyd, who was a physician of prominence as well as a Governor of Virginia, while his father was Hon. John W. Johnston, United States Senator from Virginia. Other illustrious relatives were Patrick Henry, who was a great, great uncle, and General Joseph E. Johnston, of Confederate fame.

Dr. Johnston's early education was received at Abingdon Academy, Virginia, and at St. Vincent's, in Wheeling, West Virginia. From St. Vincent's he went to the University of Virginia, where for several

years he was a student in the academic department and later entered the medical department. From the University of Virginia he went to the University of the City of New York to finish his medical education, and there he received his degree in medicine at the age of twenty-three.

After his graduation he returned to his native State and practised medicine in Abingdon until 1878, when he moved to Richmond, where he spent the remainder of his life. For a number of years after settling in Richmond he engaged in the general practice of medicine, which was doubtless of great value in developing the marked ability as a diagnostician which was noted in his subsequent career as a surgeon.

Dr. Johnston was, at various times, president of the American Surgical Association, president of the Southern Surgical and Gynecological Association, president of the Richmond Academy of Medicine and Surgery, president of the Medical Society of Virginia, a member of the House of Delegates and of the Judicial Council of the American Medical Association, delegate from the American Surgical Association to the International Medical Congress at Madrid in 1903, and had many other honors bestowed upon him.

He was connected with the Medical College of Virginia in various subsidiary capacities until 1884, when he was elected professor of anatomy. In 1893 he was made professor of didactic and clinical surgery; in 1896 this title was changed to professor of surgery and clinical surgery; in 1907, to professor of gynecology and abdominal surgery; later, to professor of abdominal surgery; and when the amalgamation with the University College of Medicine was effected, in 1913, largely through his instrumentality, he was elected professor of surgery, which chair he resigned two years before his death to become a member of the Board of Visitors of the Medical College of Virginia.

He was instrumental in the establishment of several public hospitals in Richmond, which are used for the instruction of medical students, and in 1909 he and his partner, Dr. Murat Willis, built the Johnston-Willis Sanatorium, a hospital for their private patients.

Dr. Johnston was a surgeon of very unusual ability, and he leaves behind him a host of grateful patients. His distinguished appearance and unusual personality left their impress upon any assemblage of which he was a member. He was a delightful host, and those of us who have enjoyed his genial hospitality in Richmond will long remember it. In his death our profession sustained a loss which will long be felt, particularly in the South and in his native State.

S. H. W.

George Ben Johnston was a man who had friends in every section of the country and in every walk in life. His brilliant mentality, his keen wit, his courtly manner and his distinguished personal appearance made him a prominent figure in any professional or social gathering, and his kindly courtesy to equals and inferiors alike rendered him almost universally popular.

He was a good fighter for whatever cause he thought to be just, and though the weapon he used so well was sharp, it was clean and carried no poison on its blade.

An ardent lover of his State and the Southland, his sympathies and friendships had no geographical bounds, and though one of the country's most distinguished and able surgeons, he was in touch with the wider interests of the community and gave his aid wherever he could be of service.

I will not speak of his professional life and achievements, for one better fitted than I will do that. Those of us who have been so fortunate as to share in his hospitality, his friendship and his love, who have seen him in that wonderful home life that to him meant more than all the rest of the world, cherish his memory as something beyond words, and are the better for having known and loved him.

S. J. M.

JOHN B. MURPHY

Dr. John B. Murphy was born December 21, 1857, and died August 11, 1916.

The personality of John B. Murphy was so brilliant, so striking, so forceful and intense, and still so attractive, that all who came in contact with him instantly recognized the presence of a remarkable man. Most men admired, many envied and more adored, but not many fully understood him.

During the last forties and early fifties of the past century, a most remarkable community of people from New England and the other Eastern States, and from the more advanced European countries, sent their most progressive, ambitious and capable young men and women into the new State of Wisconsin, where they could put into effect their plans, based upon a new form of practical productive idealism, which in turn resulted in the now famous Wisconsin spirit.

Into this community was born, on December 21, 1857, on a farm near the village of Appleton, this child, whose brilliancy of mind has

probably never been excelled in any youth who has entered the medical profession, enabling him to reap the full benefit of this unusual environment.

His parents had emigrated from Ireland and were fully imbued with the fact that with honesty of purpose and unceasing industry there was no mark too high to be attained by their son.

The school which he attended in the nearby village was under the leadership of Prof. R. H. Schmidt, a remarkable man, whose inspiration, systematic training and example enabled this youth to establish character, industry, logical habits of thought and a desire to become fully qualified to do things worth while.

After graduating from the High School he entered Rush Medical College, graduating at the age of twenty-two years. He entered at once upon his service as interne at Cook County Hospital, where he served with distinction for eighteen months, inspired by Christian Fenger, the father of Western surgery. He then practised medicine and surgery with Dr. Edward W. Lee for two years, when he went to Germany for twenty months, returning to Chicago in 1884. He was married to Jeanette C. Plamondon in 1885, who survives him, together with their three daughters. She has been a wonderful help to him in all his activities, as well as in taking the responsibility of his beautiful home and charming social relations.

Upon returning from Europe he became a member of the surgical staff of Cook County Hospital and Alexian Brothers' Hospital two of the largest institutions in Chicago. His great ability soon brought a stream of rare and difficult cases into his service, and he began at once to conduct a clinic for students and practitioners which became world renowned. In 1889, after extensive animal experimentation, he invented the button bearing his name, which soon made him known in every clinic in the world.

Murphy was a pathfinder and leader early in his career, especially in the surgery of the appendix, the gall-bladder and the alimentary tract, being one of the first to recognize the importance of early diagnosis and early operation of appendicitis. He also did pioneer work in the surgery of the bloodvessels, the chest and in bone and joint surgery. His use of proctoclysis has been universally adopted. There is not one branch of general surgery that has not profited through his genius.

He was a most enthusiastic and inspiring teacher in the medical department of the University of Illinois, Rush Medical College and in the Northwestern University Medical School.

In 1902 the University of Notre Dame gave him the Lartare medal:

in 1005 the University of Illinois gave him the degree of LL.D.; in 1008 University of Sheffield, England, gave him the degree of D.Sc., and St. Ignatius's College gave him the degree of A.M. He was an honorary member of several foreign surgical and scientific societies. He was Regent and one of the Founders of the American College of Surgeons and the original editor and one of the Founders of the Volume of Surgery in the American Year-book and of the Surgical Clinics. He has been president of the American Medical Association, the American Congress of Surgeons and many other societies.

A. J. O.

WILLIAM JOSEPH HEARN

Dr. William Joseph Hearn was born in Laurel, Delaware, December 27, 1842. His general education was received in the Laurel Academy; after leaving which institution he taught school for one year. On reaching his majority he entered the Jefferson Medical College of Philadelphia. In 1867 he received his degree in medicine and opened an office in Milton, Delaware, where he remained three years. In 1870 he married Amanda Prettyman, of Milton, Delaware. Shortly after his marriage he removed to Philadelphia and became the private assistant of Dr. Samuel Gross and clinical assistant on the surgical staff of the Jefferson Hospital. In 1887 he was made chief of the surgical clinic, and five years later, when Professor Gross resigned the chair of surgery, Dr. Hearn was elected a visiting surgeon to the Jefferson College Hospital. In 1894 he was promoted to the faculty and became professor of clinical surgery. In addition to his position at the Jefferson College he was surgeon to the Philadelphia General Hospital and consulting surgeon to several smaller hospitals.

Dr. Hearn died at the home of his daughter in Media, Pa., December 20, 1917. His career as a surgeon and a teacher terminated about ten years before this date, when, as the result of a runaway accident, he was thrown from his carriage, sustaining a fracture of the base of the skull.

Dr. Hearn was a man of unusual physical strength and endurance. For many years he worked day and night attending to a large "family practice," in addition to developing his skill as a hospital surgeon. Even to the end he found time, by depriving himself of needed rest, to care for many of his old medical patients.

This insatiable passion for helping those in distress was not nourished by a strong desire for riches, since a large number of these patients were of the poorer class; and even those who could afford to pay adequately for the services rendered, were often astonished at the diminutive size of the bill they received. His professional attributes were genuine even in his "business methods." His accounts were allowed to limp along in the rear, and while he never failed to respond to a cry for assistance, he often would forget to set down the charges for that response. It is said that one of his families received regularly every January a bill for the same amount, irrespective of whether that family had during the year lost an appendix, gained a new member, been afflicted with typhoid fever or had been unaffected by any malady or misfortune. His lovable disposition, kindly manner and sympathetic intuition made him an object of worship for those who had no other means of judging a physician. His diagnostic abilities and his large experience and skill as an operator made him a favorite consultant among his professional brethren. His rare judgment, his unusual common-sense, his conservative views and his safe manner of operating made him the personal surgeon of a large number of medical friends and former students, so that he was known about the hospital as the "doctor's doctor."

As a teacher he was, at the beginning of his course of clinical lectures, disappointing and unimpressive. He struck no attitude; strutted not at all; had no trick vocabulary or high-sounding phrases; never boasted even by preterition or by alluding to his wide reading and rich experience or eloquent operative results. Monotonous, unemphatic, simple language was the only vehicle he had with which to convey what all soon learned to grasp as a priceless contribution to the knowledge desired by the beginning practitioner of medicine and surgery. He talked like a preceptor to an apprentice rather than like a lecturer to a large class. Thus the disappointment at not seeing a magisterial professor was quickly submerged by the agreeable surprise of meeting a man.

Had he been less busy, more self-assertive, more prolific in publishing his ideas and results, he would have occupied a still higher place among the great surgeons that this country has produced. Nothing, however, could increase the great esteem in which he is held by his former associates, assistants and students. F. T. S.

ADDRESS OF THE PRESIDENT

By THOMAS W. HUNTINGTON, M.D.
SAN FRANCISCO, CALIF.

I am deeply grateful for the distinguished honor, of which I was made the recipient, at the meeting in Boston. The announcement came to me as a surprise beyond expression; as it is safe to say, it has come in turn to each of the men eminent in American surgery, whose illustrious names adorn the roster of past presidents of this association.

We will all agree that the advent of each of us to membership in this body was a red letter day in our careers, and an achievement worthy of any man.

For my own part I wish to assure you that my life has been made very happy by the close relationship, by the elbow touch and the helpful hand you have generously accorded to me. But what to me is more precious are the splendid friendships which have come to me. I sincerely hope they are merited and will endure to the end.

In accepting the trust you have seen fit to confide in me, I again thank you from my heart, and to this I add in all sincerity that I choose to interpret your action as an expression of affectionate regard.

Together we note the significant absence of many familiar faces. We shall miss greatly the cordial greeting of men who continuously and for many years have lent much of dignity and interest to these meetings. One and all they are conspicuous as leaders of thought and disciples of science, tireless workers in the search for truth.

But regret, if that we have, finds small place in contrast with our pride in the assurance that from us, as from a family, have gone forth a batallion of strong men, devoted and brave, to do their part unselfishly in the world's great tragedy and to bear a message from American surgeons to bleeding France and to our stricken allies.

It is an inspiration to know that fully one-half our Fellows of service age are or have been "over there."

With broader vision let us unite in splendid tribute to American surgeons, to our colleagues throughout this great country, living and dead, who have freely given their service and their lives in the cause of human liberty.

Let those of us who, for good reason, remain behind, strive to keep the home-line unbroken, Let us be mindful that it is ours to serve where service lies and, above all, to lend comfort and courage, by limitless faith, in the ultimate realization of a world redeemed.

While our voices swell the anthem to a universal and a righteous peace, let us join with Tennyson when he sings:

> "All is well! though faith and form
> Be buried in the night of fear,
> Well roars the storm, for those who hear
> Above the storm a deeper voice,
> Proclaiming all is well for social justice, human right."

Industrial Medicine and Health Insurance. The theme of today, by an abrupt departure from precedent, carries us into the realm of social economics, an interest which is engaging the best thought of all who are enrolled in the cause of human betterment.

Despite an apparent innovation I offer no apology for having ventured to discuss one of a large group of problems which have their genesis in social democracy—avowedly the most dominant, moral, intellectual and political factor in modern civilization.

This group includes several measures that are already operative through legislative enactment, providing for workmen's

compensation and industrial accident insurance. Several other very radical reforms are contemplated, some of which will undoubtedly, in the near future, be incorporated in our State or Federal statutes.

Among these are old age pensions, death benefits, pensions for widows and orphans, unemployment insurance and, finally, the most comprehensive and revolutionary of all, health insurance, whereby the medical care of the industrial worker and his dependents becomes a Governmental function.

You are doubtless aware that agitation for the legalizing of socialized medicine is widespread, and that in response to popular clamor it will, sooner or later, inaugurate a new phase of human experience in America, as it has already done in several European countries.

It may be futile, possibly unwise, to challenge the propriety of this impending reversal of form, and it certainly is not my purpose to question the altruism of its proponents. Nevertheless, I am frankly apprehensive lest the pendulum of popular desire may swing too far and lest unwittingly we find ourselves committed to the cause of making the world safe not only for Democracy but for Socialism.

For more than a century we have had repeated examples of the misadventures of Socialism. Its catchwords—liberty, equality and fraternity—were the basis of the sinister creed of the communes of 1789, of 1879 and of 1917 in Russia; a creed whose ritual though oftentimes amended and revised, still embodies too many of its insufferable tenets.

For this reason if for no other I believe that this Association should subject every feature of this "parting of the ways" to very careful analysis and be prepared to meet it with firmness, tact and intelligence. It is axiomatic that in the world's experience really beneficial reforms have been evolutionary and not revolutionary. Furthermore, America should not follow too implicitly the teachings of Germany, or even of England and France, in the solution of her social problems. Our traditions and our ideals are not altogether in harmony with those of older

civilizations. Jealous of our individual rights we are resentful of centralized compulsion and control. In a word, any scheme which proposes radically to affect our economic status should be translated into terms of American customs, American habits and American institutions.

At the close of a half-century of industrial unrest and resentment and turmoil, the American wage-earner has begun to reap the benefits of workmen's compensation and accident insurance enactments.

The history of this transition has been indelibly written; the old regime is behind us and we are living under a new social order. Very readily we recall the years when little heed was paid to social welfare. A maximum of profit for a minimum of cost was the shibboleth of business. How men of toil lived, how they fed and reared their families or what became of the breadwinner when advancing age set its seal upon their careers found small place in the day's accounting. A woful disregard for the principles of safety first was manifest, and in the onrush of enterprise little value was accorded to loss of life or limb. Safety appliances, by hesitant step and grudgingly, were finally adopted not as a voluntary concession or an economic need but as the result of aggressive legislation. It is true that provision for the care of the sick and injured was established at an early day, but this, especially in the railroad and mining industries of the far West, was founded upon the assessment plan, whereby the financial burden was carried by the beneficiaries.

As a rule there was a central organization, oftentimes a hospital, supplemented when necessary by local medical services.

The administration of funds was uniformly conducted by individual employers or corporation officials, and the amount and quality of service was limited first to the available resources and second to the efficiency of local professional talent.

Patterning after the pioneer organizations of the frontier, benefit associations of various types sprung rapidly into existence, and in almost every community came to be regarded as essential factors in industrial welfare. The assessment plan was

uniformly adhered to, though in some instances funds were augmented by contributions from employers.

In isolated instances, and under very wise direction, such foundations are and will continue to be operated successfully. But the inherent defects of such a system are obvious, and the public began to realize that the prevailing plan was inadequate and unsatisfactory.

From the beginning the compensation of industrial surgeons has been pitiably small. The value of an official appointment by corporations because of prestige has been greatly overestimated.

With some notable exceptions too little scientific interest was developed and low standards of efficiency were exacted by those in authority. Undoubtedly the scheme was fostered as an economical vantage rather than a moral responsibility.

The question of liability for loss of time, permanent injury or death was left to the conscienceless awards of the claims adjuster or to the slower and more disheartening processes of the courts.

Looking back upon the time when the ingenious but unwholesome doctrine, based upon "the fellow servant rule," "the assumption of risk" and "contributory negligence" was an established principle in the settlement of disputes between the employer and the employed, we can easily account for the recent awakening of public conscience, and the development of a keener sense of social responsibility. Likewise we discover in evolution the final cause of a reform, which is universally accepted as in the common interest of human justice and possibly as an escape from a grave national peril.

Quickly following the advent of liability and accident legislation, there has been inaugurated an aggressive campaign for provision for health insurance, which, according to Rubino, is based primarily upon the doctrine "that organized society should furnish that protection to one part of the population which some other part may need less, or if needing, is able to purchase through private insurance."

You are aware that social insurance in all its aspects bears

the legend "made in Germany," for there it had its beginning. In fact, this is one of the few accredited Governmental functions which can be regarded as of German initiative.

While her example was followed by other nations, perhaps blindly, it is by no means certain that, as an innovation, it has proved an unmixed blessing. With a clear understanding of German methods in molding public sentiment and with utter detestation of that sinister thing—German Kultur—we should hesitate long before subscribing to a dictum or a doctrine emanating from such a source.

In theory the distribution of collective losses and elimination of individual risk is fundamental in all types of insurance, and despite the fact that its application to this phase of economical need is of doubtful propriety, it is nevertheless true that health insurance has found an army of enthusiastic proponents in the ranks of welfare-workers and wage-earners.

That time-honored aphorism, "Laws are made for the greatest good of the greatest number," is coming to be too narrowly interpreted when direct class benefits are in question; and in my opinion it is clearly the part of wise conservatism to insist that the greatest measure of human justice to the majority be recognized as a more wholesome and far safer rule of organized society.

Unfortunately and too often in seeking a remedy for existing ills, immediate gain, with an undercurrent of self-interest, is the fanfare which leads to ultimate irretrievable loss. Furthermore, it may be added that those who suffer from existing ills, real or imaginary, are not always wise either as to their cause or their cure.

Health insurance in America is in its initial stage, and thus far has not been approved in any State. A bill making provision for it in the New York Legislature was found to be incongruous and impracticable and was promptly rejected. Health insurance commissions have been created in several States, and they are busily engaged in discussing details and formulating proposed statutes. At the November election in California a constitutional amendment, an enabling act, will be submitted which if

carried will pave the way for specific enactments. Very soon a widespread, aggressive campaign will be inaugurated in an effort to place this enforced remedy upon the statute books.

The attendant cost of this measure in the aggregate will confessedly be colossal. About 30,000,000 of people will participate as beneficiaries of the fund, for whom the following provisions are to be made: medical, surgical and dental care, including hospital and nursing service; laboratory facilities; radiography and appliances of various types. Conservatively the scheme will entail an expenditure of nearly $1,000,000,000 annually. Primarily this will be apportioned to the employee, to the employer and to the State in a ratio to be determined. Secondarily, it will be reflected to the taxpayer, and ultimately, as with all Governmental cost, to the consumer.

Administration of the various funds will rest with the State and thereby become an important factor in our political organization. That the expense of administration will be formidable is a foregone conclusion, and it seems inevitable that in and around the organization there will be built a gigantic machine—an engine of political conspiracy.

The consequences of this prospective cure for social ills, as reflected upon industrial enterprise, professional welfare, individual initiative and national character, are of tremendous import.

This paper, academic in tone, is limited to mere suggestion of issues that sooner or later will be joined. More careful analysis and consideration of these issues must be deferred until occasion arises.

You are, however, warned that scientific medicine is confronted by a movement which runs contrary to all traditions, a movement which will undoubtedly tend to lower potential energy and inhibit future progress. Clothed with Governmental authority, officialdom will barter the services of the profession, either individually or in groups, arbitrarily and by schedule; and compensation will be forthcoming in accordance with legal rating.

I am free to say that the time has arrived when the financial status of medical men should be amply safeguarded. Call this commercialism if you will, but let me remind you that for ages the medical profession has stood alone among all classes of society in shunning the stigmata which we have voluntarily attached to the word commercialism. The world at large places a high estimate upon financial achievement, and financial failure is universally deplored.

Success is measured by the yardstick of the banker and altruism is a byproduct of enterprise. The dollar sign is not and should not be our hall mark, but in the interests of professional dignity and of justice it is clearly our right—our duty—to conserve and protect our economical welfare.

THE PROBLEM OF HOSPITAL ORGANIZATION, WITH SPECIAL REFERENCE TO THE COÖRDINATION OF GENERAL SURGERY AND THE SURGICAL SPECIALTIES

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This subject has become a peculiarly acute and important one at this time when we are attempting to organize in the most efficient way the medical profession for war. This problem is one which I have studied for ten years or more with much care, and I desire to present briefly my conclusions. My studies of this question were made necessary and have been carried on as the chief of the surgical staff in a large teaching hospital of 400 beds, *i. e.*, the Presbyterian Hospital, Chicago (connected with the University of Chicago), where this question, the relation between general surgery and the surgical specialties, had to be met and solved in a practical way and the solution arrived at tried out in actual experience.

Further, I have studied this problem as an educational one in my position as chairman of the Council on Medical Education of the American Medical Association, especially in connection with the work of developing a medical curriculum, which was done by a committee of ten representing the ten medical subjects into which we more or less arbitrarily divided the subjects taught in a medical curriculum.[1]

[1] See Report Council of Medical Education, Fifth Annual Conference held April 5, 1909 in Chicago, published in American Medical Association Bulletin, September 15, 1909.

Further, as a member of the American Society of Clinical Surgery, I have had the opportunity of obtaining, by personal contact with the most active teachers of surgery in the twelve or fifteen best surgical clinics in this country, the scheme or organization adopted in our best hospitals and medical schools.

I have also studied this problem in the best surgical clinics in Great Britain, Germany, Austria and Switzerland.

Further I have studied this problem as a railroad surgeon for a number of years in handling traumatic cases occurring on more than 2000 miles of track. I was responsible for not only the immediate care of the injured but also had the responsibility of following the case until complete recovery of the patient, or until he was able to resume his employment, or if he was permanently injured, until I was able to determine this fact and the extent of the disability.

In this work the coöperation of general surgery and the surgical specialties was frequently called for. The gross traumatisms occurring in railroad work more closely resemble the character of the injuries occurring in war than any other group of cases handled by the civil surgeon.

Extent of Problem. As a probable or at least possible requirement, let us say that it is necessary to provide the 35,000 medical officers for the army and 7000 for the navy. The medical departments of the army and navy have adopted a general plan which contemplates giving to the American sick and wounded soldier in this war the benefit of the services of expert medical specialists.

I believe this is a distinct step in advance, and I am in hearty sympathy with this general proposition as outlined. There is, however, very great danger that it may lead to bad organization, to confusion, to friction, to poor service to the wounded American soldier, to great extravagance, to failure to employ to the best advantage the surgeons and specialists who are available to the Government for this work unless in the administration of this new plan the work of the general surgeon and surgical specialist is properly organized and coördinated. There should be no diffi-

culties in this coördination if the simple plan adopted by our best organized hospitals the world over is accepted and applied to our present war condition. A grave danger arises only when some new experiment is undertaken in this emergency and an effort made to create on short notice new specialties and new specialists and to broaden the work of existing specialists to include work which they are not familiar with and not competent to undertake; and when the effort is made to draw away from the limited number of well-qualified general surgeons available at this time a large number of men and convert them on short notice into men specializing in a narrow field, because they can be of so much greater service as general surgeons covering as they should the broad field of gross traumatic surgery. No one can question the great value of the work done by surgical specialists. Surgical specialists have earned a recognized place for themselves in surgical practice. The point at issue is simply how general surgery and surgical specialties as they exist today should be correlated so as to produce the most efficient organization.

The concrete specific problem is: How should a great mass of surgical cases, in large part traumatic, shell and gunshot wounds, be handled by a group of general surgeons and surgical specialists so as to bring about the best team work and the best results for the patients both from the stand-point of the immediate surgical care and the end-result of restoring the soldier as completely and as early as possible?

In the handling of gross surgical traumatisms such as occur in war the first and immediate care of the case is the duty of the general surgeon. In this immediate handling no anatomical division into specialists of the brain or specialists of the joints, etc., can be made. A soldier who receives a fracture of the skull and an injury to the shoulder-joint cannot be handled from the stand-point of practical administration by a specialist in brain surgery and a specialist in surgery of the joints, an orthopedic surgeon, but can be much better handled by a well-trained general surgeon who under the same anesthetic and in the same hospital takes proper care of both his brain and joint surgery. The same

general principles and the same technic are involved in gross traumatic surgery. It makes no difference what part of the man is injured, whether the head and neck, the chest, the abdomen or the extremities.

The well-trained general surgeon is better qualified than anyone else, and is in fact the only one who is at present properly qualified to take charge of gross surgical traumatisms. The surgical specialists, such as of the eye, ear, nose and throat, the orthopedic and the genito-urinary surgeons of the country, are not qualified to properly take care of the gross traumatisms of the special anatomical field in which they specialize. They have had no experience and no training in this work. For example, a gross traumatism of the face and neck, involving the nose and external ear, the larynx or esophagus, must be handled not by an ear, nose and throat specialist but by the general surgeon, because he is at present the only man who has had any training and experience in this work. And these very traumatisms are, as a rule, complicated with injuries of important vessels and other anatomical structures, such as brain and nerves, with which the ear, nose and throat man is not familiar and therefore not competent to handle. The same is true of the immediate care of the gross traumatisms of joints. These must be handled in this war by the general surgeon because he is at present the only man qualified to do this work. The orthopedic men of the country do not handle and never have handled to any extent gross traumatic lesions of joints, such as gunshot wounds, and are not competent to do so. Here again many of these cases are complicated by other lesions, as fractures of bones, injuries of great blood-vessels, injuries of other anatomical fields, such as head, chest or abdomen, and the practical administration demands that the first care and, as a rule, the care of the joints until the immediate risk of the life and limb are properly attended to must be in the hands of the one man who has had the experience and training to handle these cases, *i. e.*, the general surgeon.

The same is true of the gross traumatisms of the genito-urinary system. The genito-urinary men of the country have had,

as a rule, little or no experience in handling the gross traumatisms, shell wounds and gunshot wounds of the kidney, bladder and external genitalia. Here, again, these gross traumatisms of the genito-urinary system are, as a rule, almost always in fact not limited to this special anatomical field but involve other injuries of the abdomen, fractures and so forth with which the genito-urinary man is not familiar. These cases always have been and can best be handled in this war by the general surgeon.

Major Edward L. Keyes, Jr., in an article in the *Journal of the American Medical Association*, August 3, 1918, "Present Status of the Urology of War," makes this fact very clear. He says: "Those of us who arrived later in France after the American Expeditionary Forces had begun to establish themselves there looked around for work to occupy a urologist. . . . The situation we found was unexpected. In the armies of our allies there is practically no urologic surgery as such. Among the English the urological surgeons have all become general surgeons. . . . The reason for this situation is to be found in the material that presents itself to the surgeon's hand. At the front there is no genito-urinary surgery as such. Penetrating wounds of the abdomen which involve the kidney or the ureter usually inflict wounds of far greater importance on such adjacent organs as the lung, the gastro-intestinal tract, the liver or the spleen. . . . Thus at the front the wounds of the urinary organs inevitably fall into the hands of the general surgeons. . . . Throughout this war the specialty of surgery of the genito-urinary organs will doubtless continue in large measure as a province of general surgery. The expert knowledge of the specialist will be chiefly useful at base hospitals, but the urologist himself will be the chief gainer, for he will be pushed into general surgery of the most active sort and will thereby broaden his horizon and his surgical capacity."

The same is true of the gross traumatisms of the brain, cord and peripheral nerves. The immediate care must be in the hands of well-trained general surgeons. In this country and the world over these traumatisms are handled by the general surgeon

with the aid of an expert neurologist. The general surgeon regards as one of the important subjects in his field gross traumatisms of the head, including brain injuries, just as he does the gross injuries of the chest and abdomen. This subject has been studied and developed by general surgeons working with neurologists. There are no surgical specialists in traumatic surgery of the brain and cord. There are in the entire world but a few men who specialize in brain surgery, and almost all of their work is limited to brain tumors, epilepsy, Gasserian ganglion, hypophysis work and other pathological conditions. As far as I know but two men, Harvey Cushing and Feodor Krause, of Berlin, are the only men limiting their work to brain surgery. A number of general surgeons, such as von Eiselsberg, of Vienna, Charles H. Frazier, of Philadelphia, and Sargent, of London, have done outstanding work in the surgery of the brain. But there are, however, in the country no group of men who specialize in brain surgery, and for the traumatic surgery of the brain in this war we must depend on well-qualified general surgeons.

In regard to oral surgery as applied to gross traumatisms of the mouth, jaws, tongue, etc., these should be handled immediately by a well-trained surgeon. Working with him should be a dentist, with special training in jaw fractures.

The immediate care of the gross traumatisms coming to the regimental, aid, dressing stations, field ambulances, evacuation hospitals and base hospitals must be therefore under the direct control of the general surgeons. In the staffs of the evacuation hospitals and base hospital there should be, if practicable, a specialist in eye, ear, nose and throat work, dentists with special training and a man who can do good cystoscopic work. There should be among the group of medical men a neurologist. The evacuation hospital or the base hospital is not the place for a specialist in brain surgery nor for a specialist in orthopedic surgery. There might very properly be one or more of the general surgeons who might make under the direction of the chief surgeon a special study of brain cases, one or more who might make a special study of fractures and one or two who might make

a special study of joint injuries, but all of these men should be competent to cover the entire field of traumatic surgery and should be competent to handle in the same patient the brain lesion or joint lesion, and an injury of the chest, the abdomen and the kidney or bladder. These men should be a part of the general surgical division.

What is the special service that can be rendered in this war by the hundreds of surgical specialists who come into the medical service from civil life? It is exactly the same as that rendered by them now in their work in civil hospitals. The eye man, the ear, nose and throat man, the genito-urinary man, the dentist, etc., should not take immediate charge of the gross traumatic surgery but do the special work in which he is trained and which he is qualified to do. This work he should do in the casualty and base hospitals at the request of the internists and the general surgeon, as the surgeon in charge finds that the need for their services arises in the proper handling of a case. There is no reason for any friction in this work if handled in this way. The best of team work can be done just as it is being done in our well-organized hospitals in civil life.

The danger of friction arises only when some artificial division and relationship is undertaken or some experiment attempted. An attempt at artificial division and relationship has been introduced as a result of the enthusiasm of some surgical specialists and as a result of their earnest desire to be of the greatest possible service. In my analysis of the situation this has developed in three fields: In surgery of the brain, in plastic surgery of the face and neck and in orthopedic surgery.

Take, as an example, the surgery of the brain. An attempt to make this a surgical specialty and separate it from general surgery is a mistake and not for the best interests of the patient, or the hospital organization, or the medical services as a whole. I submit as proof of the above statement the following:

There is no such thing in existence today as a specialty of brain surgery. There are today nowhere in the world any considerable group of men devoting their time to surgery of the brain. Ninety-

nine per cent. of the brain surgery of the world is done by general surgeons working with neurologists. The few men who have specialized in brain work have limited, as I have already stated, their work largely to pathological surgery of the brain tumors, epilepsy, Gasserian ganglion, hypophysis, etc., conditions which will not be met with in war surgery. The traumatic surgery of the brain is done by general surgeons, and is a well-recognized and well-developed part of general surgery. Any attempt to make in this war and in our medical corps a division of brain surgery would be an experiment. It would be artificial and would be harmful, as the only way such a service could be created would be by taking a large group of our best qualified general surgeons and assigning them to this limited specialty. This would rob the general surgical divison of a large number of our best general surgeons who could be of much greater service acting as general surgeons and covering at the same time the traumatic surgery of the brain which they are well qualified to do. In discussing this matter I find that the general surgeons who have been offered this special assignment are desirous of doing not only brain surgery but general surgery, and they regard the artificial division of brain surgery from the surgery of the chest and abdomen and extremities as a serious mistake and not advisable. In carefully looking over this subject one finds abundant opportunity for service of our surgical specialists. The important point is to utilize them and our general surgeons in the way that they may be of the most possible service. What scheme of organization and administration should be adopted?

1. In handling the gross traumatisms of war at the casualty hospitals and base hospitals the surgical work should be done by the general surgeons with the assistance of eye, ear, nose and throat and genito-urinary men who will at the request of the general surgeon do what work properly belongs in their specialty, the work they are accustomed to do in a well-organized civil hospital.

2. There should be back of the base hospital special hospitals officered by specialists. In these special hospitals, eye, ear, nose

and throat, orthopedic, genito-urinary, brain and oral the specialists should be in complete control and the relationship between the specialists and their associates in medicine, surgery, eye, ear, etc., should be reversed from that existing in a base hospital, these latter men coming into a case at the request of the specialist who is at the head of the hospital staff.

The dangers of attempting to develop at this time from well-trained general surgeons surgical specialists in the fields of brain surgery, plastic surgery of the face and orthopedic surgery become evident when we analyze the situation from the stand-point of the number of good general surgeons there are in this country available for military service. The orthopedic division of the army contemplates securing 600 or more men to specialize in orthopedic surgery, and recognizing that there are but few orthopedic men in the country qualified to do this work, they intend to draw their supply from our best general surgeons. The brain division contemplates securing 300 men, and as there are practically not more than two or three men in the country who could be regarded as brain surgeons, they contemplate drawing upon the supply of well-qualified general surgeons for this purpose and are attempting to secure the very best men possible.

The division of plastic surgery of the face contemplates securing in the same way a number (as yet undertermined) of our best general surgeons for this work, let us say 100 men. This makes altogether 1000 men. The number of well-trained general surgeons of the country who are capable of acting as chiefs of the surgical work of a large hospital, say of 1000 beds, and who are available for military service, is certainly not more than 1000 men. If the plans of these special surgical divisions were carried out it will rob the general surgical division of the very men who should be placed in charge of the general surgical work of our military hospitals.

The great bulk of these 1000 well-trained general surgeons would personally much prefer to take charge of a general surgical service and do the general surgical work of the head, neck, thorax, abdomen and extremities and not limit their work to a special

field such as brain or plastic or orthopedic surgery. They can be of much greater service to the country if the work is organized so that they can cover this broad field than they could possibly be if their work was limited to some smaller anatomical division.

The practical solution of our problem is to recognize frankly the existing state of facts and the limited supply of well-qualified, general surgeons in this country and use them where they can be of the greatest service. The supply of surgical specialists such as eye, ear, nose and throat, dentists and orthopedists in the country is ample to meet the actual demands of the service, and there is no doubt that a sufficient number of these men can be obtained to do the work which properly comes under these specialties, and for which they are well qualified. There will be no difficulty in securing men in general medicine and general surgery, and the medical and surgical specialties to give our troops the highest class of medical and surgical care provided the organization is developed and administered along the accepted and best lines. The difficulty presents itself only when in this emergency some new and artificial division of work is attempted, some new experiment tried.

One might stop and ask who and what are responsible for the new and artificial divisions and schemes of organization which have been advocated. The answer to this is easily found in the great enthusiasm and desire of some active men in these special fields to see that the American soldiers receive the very best possible special service that their specialty is capable of giving. These men have with admirable self-sacrifice thrown themselves actively into this work, with the conception that each brain case should have the special service that an expert brain surgeon can give, and that the orthopedic cases should have the special services that an expert orthopedic surgeon can give. With this idea in view they have suggested the experiment of making in the midst of this war emergency several hundred special brain men and orthopedic and plastic specialists out of general surgeons by about four to six weeks' brushing up courses in these special fields.

The answer to this is that this is no time to experiment. A few special brain and orthopedic and plastic and oral hospitals should be established well back of the line where surgical specialists can give properly selected cases the benefit of their services. But this is no time to experiment with a new scheme or to reorganize along new and untried lines the field of general surgery and surgical specialties. The American soldier when first wounded should have the benefit of the services of our best general surgeons, such men as Blake and Brewer, Finney and Crile and the many other general surgeons who have made their services to the Government available.

The practical difficulties arising in the administration of a new and experimental scheme of having surgical specialists take immediate charge of the wounded are insurmountable.

If the war continues for some time there will be unfortunately plenty of work for all of our general surgeons and surgical specialists.

The question which must be answered in this particular problem is how can the surgical work in our military hospitals be so organized and administered and correlated that the wounded American soldiers can receive the best possible service, and how with the material on hand can we use our general surgeons and our surgical specialists to the best possible advantage? It is not a question of limiting or enlarging or magnifying the importance of any special field, but a question of doing the best possible team work for the benefit of the wounded. With that single idea in view I desire to present the following summary of the facts involved in the problem with an outline, not of a new scheme of organization and administration, but of the simple plan of organization and administration which is today recognized the world over as the generally accepted and best scheme, and to urge that in this great war emergency, in the organization of our surgical work, this accepted plan be followed, and that any experiments and rearrangements be left to the slow process of evolution after the war.

The organization and administration which should be adopted

in order to secure the best coöperation between general surgery and the surgical specialties:

1. We should adopt the plan of utilizing the services of both our general surgeons and our surgical specialists.

2. The scheme of organization and administration of the various surgical divisions in military hospitals should be along accepted lines as in our best civil hospitals.

3. In the hospitals close to the line, including casualty and base hospitals, which will have the early management of the gross traumatisms from shell wounds and small-caliber bullets, the organization should be so planned that the general surgeons should have charge of these gross traumatisms irrespective of the anatomical location, and the few surgical specialists on the staffs of these hospitals should do such work as is assigned to them by the surgeon in charge.

4. Well back of the line there should be developed special hospitals, orthopedic, head surgery, special fracture hospitals, etc. In these special hospitals the surgical staff should be so organized that these specialists have complete control of the management of the cases. There should be on these staffs a few men representing their special fields, such as internal medicine, neurology, eye, etc., and these men should do such work as they may be called upon to do by the staff of specialists who are in charge of the hospital.

5. The effort made to establish schools in special departments giving special instruction, in surgery of the brain, fractures, orthopedics, etc., should be continued and amplified as much as possible. These schools should be devoted to special fields of surgery and should give short courses reviewing the work of a special field, especially from the stand-point of the experience obtained in this present war. These schools should not attempt the impossible task of creating in a short period specialists in these particular fields but should be regarded as furnishing courses of instruction to general surgeons which will make them more competent in these special fields of work.

6. The specialists in charge of the special hospitals to be created well back of the line should be drawn not from the students taking these special courses but from the body of our well-trained specialists who are now available.

In the organization of the reconstruction hospitals which are being created in this country for the important purpose of reconstructing and reëducating the wounded men sent back from France the same scheme of organization should be adopted. The work will cover the entire field of medicine, and it cannot be placed properly under the control of a single specialty. It will require the coöperation of all departments of medicine and surgery, and the medical organization therefore must be along the same broad lines that have been found by experience practical in our best civil hospitals.

And, finally, I believe that it is possible to secure for the American soldier, provided we adopt the proper organization, better medical and surgical care than has ever before been furnished to any army in any country, because I believe that never before have so many well-trained medical men made their services available to the Government.

RELATION OF ORTHOPEDIC TO GENERAL SURGERY

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The task that confronts our Government of caring medically for the soldiers of our army is so great that it is our duty to see that unnecessary difficulties are not created by either avoidable lack of knowledge or positive misunderstandings. Otherwise harmony is lost, antagonisms are created and efficiency destroyed. There seems to be some grounds for believing that a certain amount of lack of knowledge and even of distrust exists regarding the work of the military orthopedic surgeon, not only among the line officers, but also the military surgical staff. This will, I am sure, disappear when the proper sphere of the orthopedic surgeon is once known. He is a newcomer in the military field, but he is no interloper. He did not enter unbidden. A need was felt for his services and he was asked to help. The reason his aid was requested was because a large amount of work was necessary to be done and he was the only one qualified to do it. He appears at this time because work of an entirely new type is required which heretofore has been neglected. A higher standard is required of the soldier and better care of his necessities is demanded. For these the services of an orthopedic surgeon are essential.

When the line officer knows how much the orthopedic surgeon can improve the condition and increase the efficiency of his men he will welcome him and utilize his services, and when the general surgeon realizes that it is neither the mission nor the desire of the orthopedist to appropriate his cases or interfere with his prerogatives then will he not only be tolerated but perhaps consulted with and treated as a colleague and co-worker in a different field.

The necessity for the orthopedic surgeon has arisen from the fact that cripples of all kinds must be restored, as far as possible, to serviceable condition. I am afraid that neither our people nor our Government as yet fully realize that the time has passed when the disabled soldier can be cast on the community with his wounds healed but still unprepared to meet the necessities arising from his changed condition. Most of these cases can and should be so improved and trained as to fit them to be to a greater or less extent self-supporting and independent of public and private charity. To do this requires a different and more extended treatment than has heretofore been attempted and specially educated surgeons are necessary to carry it out. Our land has numerous hospitals and many able surgeons to treat emergency cases. The limit of stay in many is set at three months, but for cases demanding treatment for from three months to a year or more, we have made little or no provision. I know from considerable experience how the general surgeon feels when he finds four or five of his surgical beds occupied by tuberculous bone or joint cases, osteoarthritics, and other human wrecks. Many of these cases present no interest from an operative stand-point and they cannot be treated effectively by any other than the most exacting, time-consuming, and troublesome means. The general surgeon is not to be blamed for his attitude toward this class of cases, because they are not in their proper place, they belong somewhere else.

It is not desired to make any plea for the military orthopedist: If he is not needed and not wanted, put him out, but then the work he does must be done by the general surgeon and it behooves him to qualify himself for the task, and this he has neither the time, the facilities nor the inclination to do. The general military surgeon is amply occupied with attention to matters of sanitation and the general health of his troops in camp and with acute surgery and wound treatment in active service or in the hospitals. He is called to do all the visceral surgery he is able to do and more of the surgery of the extremities than he desires to do.

A man recently presented himself who was injured three years ago. He was wounded by shrapnel and still had a paralysis of

the ulnar nerve, an ununited fracture of the ulna and a stiffened elbow. The general surgeons had saved his arm but surely no one would begrudge an orthopedic surgeon trying to recover something useful from the remains? The mission of the general military surgeon is to save the lives and limbs of the wounded and the mission of the orthopedic surgeon is to follow and patch them up. The type of work done by the two is absolutely different and neither interferes with the other. Remember that 30 to 50 per cent. of the wounded requires this subsequent patching up, and who else is there to do it?

Even the care of the feet is so intricate and time-consuming as to require one specially qualified to attend to it. Notwithstanding that fact most general surgeons will of necessity have far more of it to attend to than they desire. What general military surgeon wishes to travel about with a cobbler's outfit and blacksmith shop added to his kit? Yet that is what he should have if he is going to do orthopedic work. What general surgeon has the time to spend with superintending massage, and hydrotherapy and passive motions in an interminable struggle to restore stiffened fingers and other joints to some degree of usefulness? Is he willing to see that an artificial leg is made comfortable and fulfils its object? Is he willing to teach a right-handed man to use his left hand? Is he willing to educate the cripple in new fields and vocational training to earn his livelihood? If he is willing to do all of these and many others like them, then let him forsake the field of general surgery and join the great brotherhood of orthopedic surgeons. They will welcome him with open arms and his time will be not only well spent but fully occupied. If he is a good operator, so much the better. The operations he will be called to do will not be brilliant, but most scientific, difficult, tedious and painstaking, designed solely for utility and always conservative in character and requiring long-continued after-treatment with all the resources of mechanics as well as art. I trust enough has been said to show that there is not the slightest antagonism between the general and orthopedic surgeon. As a rule the former has first choice and can retain such

cases as he desires and the latter does not wish to have the cases that the former can attend to. The general surgeon tries to get his cases out of his wards as soon as possible but the orthopedic surgeon tries to keep them in as long as possible. One simply supplements the other, they are not rivals but co-workers. Each has his separate duties, his separate field. There are room and need for both.

Let me then plead for a cordial relation between the two—we are all working for one end, and after all it is team-work that counts.

THE APPLICATION OF THE TEACHINGS OF WAR SURGERY TO CIVIL HOSPITAL CONDITIONS

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The war has emphasized many things, a careful consideration of which should prove of value in connection with surgery in civil hospitals. One group of facts has to do with the general organization of our hospitals, another with the pathology, bacteriology and treatment of traumata and infectious processes. We desire to present certain aspects of both groups for your consideration.

The war had been in progress but a few weeks when it was amply demonstrated that all previous training of surgeons had left them hopelessly deficient in the knowledge of wound processes. Conditions strikingly similar to those present in our Civil war were developing. To quote Moynihan:[1] "Suddenly the surgeon was confronted with a large succession of cases in which a raging, and often a rancid, suppuration was present, and he found that all the old remedies upon which he had so comfortably and confidently relied were hopelessly inadequate and futile. A challenge was, so to say, thrown to the profession, and I think we may now, with due modesty, claim that it has been splendidly and triumphantly met. Rebukes and taunts at our incompetence were not seldom heard in those far-off days." It is not unfair to say that some rebuke was, to a certain extent,

[1] Treatment of Gunshot Wounds, Surg., Gynec. and Obst., No. 6, xxv, 583.

deserved in that surgery had neglected one of its opportunities. The development of aseptic surgery following the teachings of Lister and Pasteur was so rapid; the advance of the operative field into the abdomen, the cranium and the thorax held out such enticing promise; the work entailed was so clean cut, so attractive and so productive that the best minds were centered upon it. The less congenial, less striking and less comprehended field of badly traumatized and badly infected tissues was overlooked. There was no general grasp of the fact that such cases were appallingly plentiful in civil life and that they occurred to a great extent in patients in the prime of their productive life. Their care was relegated to a secondary place and the custom of considering them as the special responsibility of the junior members of the visiting staff, or even the house staff, while not universal, was more or less general. This resulted in a perfunctory routine treatment, founded in most instances upon incomplete pathological and bacteriological knowledge. A tradition gradually developed that these cases at best must terminate in some degree of permanent disability and that no form of treatment would appreciably improve the results. In time the junior surgeon passed from what the majority found uncongenial work, and entered more and more into the competitive field of major operative surgery. Thus untrained in traumatic work he reached the period of his greatest productivity, but had no occasion to apply his developing powers of sound judgment to the cases which constitute the vast majority of war casualties.

Under such conditions it is not surprising that the horrors of the war found the surgeons unable to cope with them. The older men were confronted with a disease process to which they had given no consideration for many years and the younger men suddenly found themselves overwhelmed with this thing which they either had put behind them or soon hoped to. We cannot help feeling that our lack of foresight merits a reproof.

Has there been any lack of opportunity during the past thirty years to have learned nearly all the lessons that the war has taught? Could we not have fathomed more of the secrets of

wound infection and healing? Has a compound fracture been such a rare thing that more knowledge expressed in an authoritative way has been an impossibility? Answers to these questions must indicate the failure to have profited by our opportunities. The defect has lain in that there has not been sufficient insistence on and striving after an improvement, the need for which has been strongly or dimly felt by all the thinking members of the profession. The needed improvement is along the line of a definite reorganization of our entire hospital plan. The war has now demonstrated, so that all may comprehend, how this should be accomplished. If, as Moynihan says, the surgeons have triumphantly met the challenge thrown to them, there has been one all-important factor in their ability to do so, the fact that they worked under a one-head organization.

The military situation has made it possible for the surgeon to call to his aid physicists, chemists, pathologists and bacteriologists. He had not been dependent upon a casual contact with these trained minds who have formerly been so content to expend their intellectual force upon abstract scientific problems, the benefit of which he, as the clinician, was expected to apply to disease processes without help. To actually see, feel and know the bedside problems was to them a matter of little importance, a field scant in fruit, and in the opinon of some beneath the dignity of a highly trained scientific mind. If the clinician did not find the time to make his home in the laboratory as well as in the ward and operating room he was considered of inferior caste, yet the laboratory workers showed no inclination to come to the surgeon. How earnestly and futilely have we invited, urged and cajoled the well-trained men of our laboratories to come to our wards and operating rooms and give us the aid their training entitled us to expect from them and by first-hand observation see the difficulties with which we are confronted. These confrères sent us a pathological interne who entirely satisfied them by bearing culture tubes and surgical specimens back to the laboratory to receive routine treatment without regard to the great underlying clinical and pathological principles.

Surgeons have felt the hopelessness of such a situation and individuals have made successful efforts to obviate it by having a ward pathologist and bacteriologist attached directly to the clinical staff. These, however, were young men with limited experience and could not bring to the study of the clinical problem a sound judgment founded on long experience in a laboratory closely related to clinical study.

The war has demonstrated, beyond further debate, that corresponding progress will only be made in our civil hospitals if the patient is made the center of all its activities. The wards and operating room must have a staff of laboratory men just as they have a staff of surgeons. The art of surgery and the sciences on which it is founded cannot be compassed within the mind of one man. The laboratory scientist will be more productive by close contact with the surgeon and the surgeon will equally profit. These staffs must be composed largely of full-time men. Our military surgeons and laboratory men find no distracting calls outside the hospital. No one can conceive that the advances made in three years could have been possible if the best-trained mind had spent three or four hours a day at the hospital and then left them to get on as best they might during the remaining twenty hours under the sole care of juniors and internes. It may be argued that to organize our hospitals on such lines will prove financially impossible. Such argument cannot be maintained. Money has always been forthcoming to foster any well-thought-out plan for the betterment of education and the best care of the sick and injured. Had such lessons in the treatment of the injured as this war is teaching been in force during the past two decades the money saved to our industries would have more than met the expense involved in having learned them. The duty of impressing this lies with our profession, and upon the success obtained depends our ability to give to the country one of the offsetting benefits with which war, to some extent, balances its horrors.

Another more easily accomplished phase of organization has also been placed in evidence in the military hospitals. Every

service has had at its disposal well-trained mechanics and carpenters. Most surgeons in civil hospitals have vainly struggled to get a simple piece of apparatus constructed to meet some special requirement. There was no well-equipped shop at hand with a competent workman who could promptly furnish the apparatus and at the same time suggest ways of meeting mechanical problems for which his training fitted him. Trustees of hospitals have been very loathe to recognize that other artisans than surgeons might be advantageously employed in a surgical service. The results abroad should be very effective in convincing them that this view is no longer tenable. The accompanying table contrasts civil and military hospitals, and suggests the lines along which reorganization should take place.

COMPARISON BETWEEN THE ORGANIZATION AND PROFESSIONAL ACTIVITIES OF CIVIL AND MILITARY HOSPITALS

Military Hospital	Civil Hospital
One commanding medical officer whose authority, under army regulations is supreme.	No such officer, whose authority can be exerted in a correspondingly efficient manner.
All member of the staff are on a "full-time" basis, and give their undivided attention to the work within the hospital.	In most instances none or but few of the members of the staff, other than the house officers, are on a "full time" basis.
Absolute correlation of all departments and activities, with the object of returning the patient to duty at the earliest possible moment.	No close correlation between the several departments, administrative, clinical and laboratory; each department being independent of the others, instead of responsible to one supreme commanding officer.
Each department a dependent means to the end of securing the greatest benefit to the individual patient.	Each department an independent unit, concerned more with its own problems than with a mutual coöperation in the solving of common problems.
Within each department, all strictly departmental policy is controlled by the chief, with the approval of the commanding officer.	This does not obtain in most hospitals, and is absolutely lacking where a rotating service exists.

Military Hospital	Civil Hospital
Military medical organizations must receive and care for all cases coming to them, and can only be relieved through the regular channels of evacuation or by the termination of the case in cure or death.	Civil hospitals may or may not accept a patient for treatment depending on the type of case, thus delaying the initiation of adequate treatment.
Incoming patients are seen by an officer of mature judgment who is capable of making such immediate disposition of the case as will best meet the needs of the patient.	Incoming patients, even when in serious condition, usually seen by a house officer of immature judgment who carries no power to initiate definitive treatment.
The chiefs of the services or fully qualified associates are always on duty, prepared to take immediate action when required.	Except during hours of "round," emergency cases must await the arrival of a qualified member of the visiting staff or accept inadequate treatment.
Laboratory examinations, including *x*-rays, may be made immediately on admission, while patient is en route to the ward.	These examinations are ordinarily not made until after patient has reached the ward and requests have been made through elaborate channels, involving loss of time and additional handling of patient.
The laboratories, including *x*-rays, are available at any hour of the day or night, and have a staff of assistants adequate for the heavy work they must perform.	Laboratories, including *x*-rays, available only during specified hours or days, and usually understaffed for the work to be performed.
The clinicians are assisted by a staff of trained mechanics, who are able to prepare or devise apparatus for the treatment of fractures, etc.	Rarely are trained mechanics associated with the hospital for the purpose of manufacturing apparatus for patients.
The patients must be held in hospital, or evacuated to an equally competent hospital, until all wounds are healed and the patient is fully able to return to his duty.	Too great a tendency to the early discharge of cases, in order to secure beds in an overcrowded inelastic system and failure of the outpatient department to exercise an adequate control over the discharged patient.

Taking advantage of the opportunities which a well-organized army medical corps gave to them the English and French used the enormous number of wounded coming under their care to speedily master some of the principles underlying the treatment of war injuries. The application of their teaching to our work in

Bellevue Hospital, where there exists a large traumatic and infected service, constitutes the second point which we desire to discuss.

Four definite principles may be accepted as having been established: (1) severe traumata, badly contaminated with bacteria, need not go on to active infection and suppuration; (2) these sequellæ are largely the result of certain physical as well as biological factors; (3) if these sequellæ do supervene they may be largely controlled by removal of the physical factors rather than by killing the bacteria; (4) a seeming paradox, aseptic surgery is not confined to clean operative wounds made through carefully prepared tissues. To test these principles under civil conditions we utilized assignment by the Surgeon-General's Office to give instruction in fractures and war surgery at the Cornell Medical College and Bellevue Hospital. All traumatic cases and all important infectious cases were made a special service. The number at our disposal is on an average between thirty and forty. The range of cases is large, and during the seven months the work has been in progress there has been sufficient of each type to permit of rather definite conclusions. We had associated with us the heads of the departments of chemistry, pathology, bacteriology, physiology and anatomy, and being bound together by the common interest of teaching medical officers the work was from the start closely correlated; thus, to some extent, giving us a semimilitary organization. For a point of departure we selected a study of the chlorine antiseptics.

Our first concern was to establish our practice exactly on the lines taught by Carrel, De Page, Dehelly, Dakin, Dunham, Daufresne, Lee, Furniss and others who have had the imagination to conceive and the patience to develop new procedures. Following closely the writings of these men and the practical experience of one of us (E. F. B.) at the Rockefeller War Hospital we had little difficulty in perfecting a smoothly running service in a few weeks.

Every detail of the Carrel-Dakin method with the sodium

hypochlorite was observed and the method as described by Lee, Furniss, Sweet and others for using dichloramine-T, received equally close attention. We had no difficulty in practically banishing pus from the wards, and with a few notable exceptions the worst suppuration could be controlled in a short time. Immediately the question arose as to whether the results obtained were due to the more intensive care and study or to some inherent value in the various steps followed. Undoubtedly the former is an important fact, but after seven months' very close observation and analysis we have concluded, beyond question, that the treatment of most suppuration is definitely improved by the employment of the hypochlorite solution. We, however, are not prepared to accept the hypothesis that its bactericidal action is of paramount importance. This property is a definite aid in efficiency, but in another more potent attribute lies its greatest virtue.

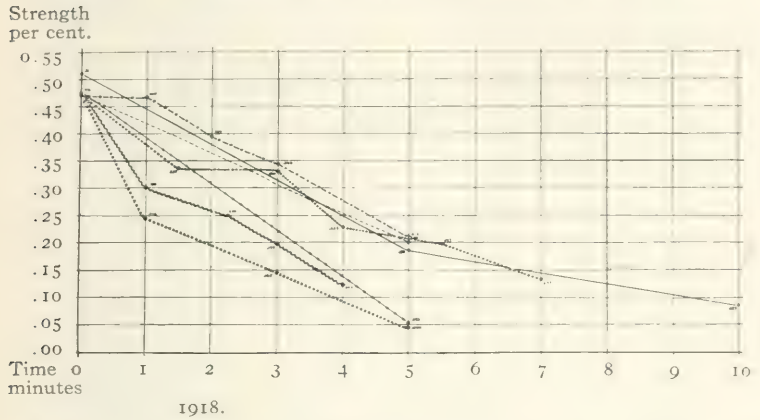
Sodium hypochlorite in a watery solution of 0.45 per cent. to 0.5 per cent.—the limits prescribed by Dakin—is strongly proteolytic. It is more able to digest protein in dead form than in the form of living protoplasm, though it can undoubtedly attack the latter. The splitting action is brought about by an interchange of the "active chlorin" in the hypochlorite solution and the hydrogen in the amino group of the protein. A chloramin first forms and then a dichloramin. The reaction probably does not stop here and a further substitution of chlorin takes place. The exact nature of this later stage is not, as yet, established, and in this substitution bacterial protoplasm, if present, is killed, but more soluble compounds result, and this is a helpful fact.

The reactions are in no sense specific. The protoplasm of bacteria is attacked with no more avidity than is that of the protein on which the bacteria live. Living human tissue possesses, however, a strong defense against digestion. When the hypochlorite solution comes into contact with it an immediate response is the outpouring of tissue fluids containing an abundance of protein in solution. This dissolved protein at once takes up the available chlorin and in less than one minute the hypochlorite falls below the Dakin strength, and in the conditions ordinarily

obtaining in its therapeutic use a negligible amount of available chlorin is found at the end of ten to fifteen minutes. The accompanying Chart illustrates this as determined in various types of the pathological lesions. If the wound under treatment contains an abundance of bacteria, more or less destroyed leukocytes and necrotic débris, the first reaction is with these substances rather than with the tissue fluids freshly poured out. Thus the bacteria are killed, the necrotic material is dissolved and the surface of the wound becomes clean. If, on the other hand, the test is made with an already perfectly clean, granulating surface there is less immediately available protein and the hypochlorite strength is less rapidly, though markedly, lowered. It is interesting to note that for this reason skin irritation very rarely takes place around wounds of the former class even though no particular attention is paid to its prevention. On the other hand, when a wound is nearly or quite clean and the less changed solution flows over the skin an irritation will take place unless the skin is protected. Knowledge of this fact is helpful in doing the dressings, because only when the acute suppurative stage of the wound has been controlled does one need to watch all the detail of skin protection. Another observation in this connection is of interest. Unless the amount of Dakin solution is in great excess, skin-burns always remain very superficial. The explanation lies again in the fact which we desire to emphasize, that Dakin solution in contact with any body fluids ceases almost immediately to be Dakin solution. The superficial burn pours out albuminous fluids, hence the solution immediately loses its power to burn.

Early in our experience we encountered a case which, at that time, baffled our attempts to explain the sequence of events. With our present conception of the problem the explanation is forthcoming. The patient was admitted with his arm torn, crushed and fractured beyond possible repair. He refused amputation for more than forty-eight hours, by which time complete gangrene and a high grade of infection had developed. Disarticulation at the shoulder-joint was done and treatment with

FALL OF STRENGTH OF DAKIN'S SOLUTION IN WOUNDS



1918.

1. ———— Jan. 17. Large nephrectomy wound, with fecal fistula. Moderate soiling with feces.
2. –·–·–·–·– Feb. 25. Same wound as No. 1. More soiled with feces than in No. 1. All traces of "active chlorine" gone in fifty minutes.
3. – – – – – – – Mar. 28. Carbuncle of neck. Slight amount of necrotic tissue still present. All traces of "active chlorine" gone in one hour and twenty minutes.
4. –·–·–·–·– Apr. 25. Abscess of thigh. Old wound; clean; covered with healthy granulations.
5. ..... Apr. 25. Empyema, right pleural cavity. Readings made at operation.
6. ××××××× May 22. Empyema, right pleural cavity. Readings made twenty-four hours after operation.
7. ~~~~~~ May 22. Empyema, same as No. 6. Reading made immediately after No. 6.

Explanatory Note

Curves 1 and 2 were made from the same wound on different dates. At the second reading the wound was much dirtier and there was more material within it, with which the Dakin solution could react, and the fall of strength has accordingly been more rapid.

Curve 3 represents the fall in a comparatively clean wound.

Curve 4 also represents the fall in a very clean wound, in which there was little exudate. It will be noticed that the fall in strength during the first minute was negligible. Thereafter, when the exudate was poured out from the walls of the wounds, the fall followed the rate noted in the other wounds.

Curve 5 was made from a wound which had immediately before been flushed with Dakin solution, and therefore a considerable amount of the purulent exudate had already been washed out of this cavity.

Curves 6 and 7 were made from the same wound, an empyema. Curve 6 was made without any prior flushing of the empyema cavity.

Curve 7 was made as a second reading after the empyema cavity had been flushed once, and in this second reading the fall in strength was not so rapid as in the first reading, when the cavity still contained a small amount of unchanged exudate.

hypochlorite solution immediately instituted. The suppuration was promptly controlled, except that a little pus could always be found deep in the wound at the glenoid fossa. This was never more than a few drops, but it served to keep the bacterial count high and prevented the final healing of the wound. One tube was regularly led to this point and the fossa was kept intermittently bathed in fresh solution. Investigation by opening the wound showed necrosis of the glenoid cartilage. This poorly nourished tissue was not able to throw out sufficient fluid to neutralize the full-strength hypochlorite poured upon it, and hence was itself destroyed. Removal of the cartilage and bathing of the more vascular bone resulted in a prompt healing, with complete closure of the wound. Had we fully comprehended this fact and protected the cartilage with the vaselin mixture as we protect the skin the healing process would have been much hastened and the cartilage would have lived. This experience with our misconception of its nature led us to believe that Dakin solution should not be used in joint cavities or in contact with tendons and other low vascularized tissues. Therefore when a patient presented himself with a badly infected knee-joint, showing a streptococcus, we opened it by two lateral and two posterior incisions, applied traction and washed the joint intermittently with ether or normal saline solution. His progress was distinctly bad. The suppuration burrowed, the knee condition became more and more advanced and resection, or even amputation, seemed our only resource. Arguing that in any case the knee would have to be sacrificed and the hypochlorite could do no worse its use was instituted. Suppuration was controlled very promptly, the joint cavity cleaned up, extension lines down to the leg and up the thigh showed healthy granulations and the final result is a knee-joint far from useless. It was this unexpected result, when compared with the necrosis of the glenoid, which brought out the fact that cartilage and synovial membrane, already the seat of severe inflammation by infection, will not be damaged by hypochlorite. The hypochlorite attacks and is chemically satisfied by the products of this inflammation and the joint structures

are aided by its action. The rule is thus formulated that recently injured joints in which suppuration has not taken place should not be exposed to hypochlorite. The response in tissue fluids may not be sufficient to protect joint structures from erosion. On the other hand a joint already infected and filled with purulent exudate may and should be so treated, because the damaging tissue will be digested away and the joint cavity returned to a more normal condition. Sound judgment must determine the degree of infection which should or should not be irrigated, the placing of the tubes within the joint, the amount of irrigation and the period at which it should be discontinued.

Our ideas as to the treatment of empyema have undergone an evolution similar to that of joint infections. Appreciating that the hypochlorite solution is very destructive to the peritoneum, pleura and endothelial membranes in general we at first scrupulously avoided using it in the pleural cavity. The non-digesting chloramin solution 0.5 per cent. to 1 per cent. was substituted in some cases. While this exerted some possible influence in changing the discharge from a purely purulent character to the less offensive mucilaginous type it did not seem to hasten healing.

Reports came to us that other hospitals were boldly using the hypochlorite solution, even going so far as to fill the cavity immediately after evacuating the pus through a rib resection and plugging the opening in order to get the solution in contact with every part by exerting gravity pressure. These experiments were watched with interest, but our understanding of the processes involved was too meager to permit emulation of this courageous procedure. As the true properties of Dakin solution unfolded themselves, and we fully grasped the fact that contact with purulent material almost instantly destroyed its digestive power *in vivo* as well as *in vitro*, we felt willing to investigate the subject by actual clinical means. The chart already presented shows the results. The only possible damage can result when full-strength Dakin solution comes in contact with an unaltered pleural surface. As this is hardly conceivable, if caution is used

in avoiding pressure, we arrived at the conclusion that the Carrel-Dakin method is applicable to the treatment of empyema.

Since, however, fluid put in the pleural cavity under pressure may very readily force its way beyond the infected portion and gain entrance into portions of the cavity possessing normal pleura we deprecate its use in this way. A second determining factor in this conclusion is also found in the well-known fact that irrigation of an empyema cavity under pressure with any fluid has, in the past, caused many cases of alarming collapse and even death. The reason for this, so far as we have been able to learn, is problematical, but the danger is none the less real. Our later practice, therefore, has been to perform the usual rib resection under local anesthesia, evacuate the pus and so far as possible remove all gross coagula of lymph. Tubes are then inserted, and with the patient so placed that an easy egress of the solution is maintained, Dakin solution is slowly run into the cavity under low pressure. Any violent coughing or embarrassment of respiration or pulse is a signal to stop the procedure. Hourly or two hourly irrigations are instituted, the amount being regulated so that each irrigation washes out all that remains of the preceding and fills the cavity with fresh solution, due attention always being paid to the avoiding of overdistention.

Our experience leads us to believe that in this method an advance in the care of empyema has been made. The patients convalesce more rapidly, the purulent discharge ceases sooner and secondary pocketing is less frequent. In no case, however, have we duplicated the results reported to have been obtained in some clinics wherein well-developed empyemata have been rendered surgically clean in five to nine days, with secondary suture of the chest wall resulting in complete healing.[1]

We have not thought it necessary before this gathering to emphasize the fact that in all our work we have done our utmost to insist on the well-established principles of surgical procedure in infected processes. Surgical incision in every instance takes

[1] Since writing the above such results have been obtained by us.

precedence over all else. Ample drainage is never neglected. No line of reasoning based either on our own experience or on the teaching of others has led us to accept the idea that hypochlorite acts better in puddles than in a properly arranged irrigation with drainage. We only puddle when, surgically, it cannot be avoided.

To sum up our studies in the mode of action of Dakin solution we believe it possesses three important properties:

1. It is a powerful digestant of protein substances.

2. This includes the protein of bacteria, hence it is a bactericide.

3. It stimulates wound surfaces to pour out albuminous materials and leukocytes, hence it still further destroys bacteria.

These three properties combined give it its undoubted power to clean the surface of infected, suppurating wounds. In our experience we find its proteolytic power more important than its purely bactericidal. Hence its greatest use is in wounds in which infection is well established and an abundance of more or less devitalized necrotic tissue is present.

A full realization of these conceptions clears away much of the misunderstanding that has been prevalent concerning the use of Dakin solution and answers the charge against it that not being specific for bacteria, any such powerful bactericide must necessarily be destructive of living body tissue and thus destroy body defenses. On the contrary it destroys the bacteria and at the same time draws out locally the body defenses (see Chart, Curve 4.) This understanding of the action of sodium hypochlorite has proved most helpful to us in applying it to our cases and in determining its field of usefulness and its limitations. In the last analysis the healing of any wound, whether clean or infected, is a property of the tissue involved plus the general physiological activities of the whole body. If these be deficient, either inherently or relatively, as compared to the virulence of infecting organisms, the infection cannot be controlled no matter what form of antiseptic or physiological treatment is applied. This is amply demonstrated by one case suffering from a severe thigh infection, with a virulent streptococcus. The local sup-

puration was easily got under control, but the patient died from a streptococcemia, with positive blood cultures. Anderson and Richardson[1] report a similar case in which this was the final cryptic note on the chart: "Wound almost healed—patient dying." Again, we can cite cases suffering from constitutional disease, in which the local condition progressed satisfactorily, though not ideally, and metastatic infection developed in distant parts, the same organism being present as that found in the original wound. Blood cultures in these cases were negative.

These considerations conversely lead one to the conclusion that Dakin solution is not indicated in cleanly traumatized tissues. When therefore a recently wounded patient can be adequately treated by the now established procedure of thorough mechanical cleansing and a careful complete excision of all damaged tissue and foreign materials it is supererogation to apply Dakin solution. The tissues are able to cope with any remaining bacteria successfully, and one is dealing practically with the condition found in a surgical wound made under the usual operating technic. Primary suture may be done, with a strong hope that primary union will result. This in war conditions has been realized in about 80 per cent. of the cases. In civil conditions we find this percentage is hardly to be expected, because the crushing, tearing injuries inflicted by machinery and run-over accidents are often more extensive even than those caused by war missiles.

Care in selecting the cases has, however, demonstrated to us that primary union can be more often obtained than heretofore had been believed. Under all conditions, however, when this is sought for, there will be a certain percentage of failures, and active suppuration will supervene. Nothing of which we have any knowledge is then so efficient as Dakin solution in controlling this complication and restoring the wound rapidly to a condition where secondary suture may be successfully done.

Moynihan, in discussing the relative merits of the Carrel-Dakin treatment with secondary suture and the careful mechani-

[1] Septicemia as a Complication of Gunshot Wounds, British Jour. Surg., No. 19, v, 393.

cal cleansing and efficient surgery, with primary suture in very recent wounds states that the results are about equal. He adds: "To put this statement in what may seem an extreme fashion, it may be said that the Carrel-Dakin method has achieved its greatest triumph in cases where it need not in fact have been applied." This does not imply, as might be inferred, that the method is without value. It simply means that this method is not called for in recent wounds, *i. e.*, six or eight hours after injury, those which are contaminated only, but in which the contamination has not developed to an actively growing infection or suppuration. Of this treatment for the latter condition Moynihan speaks with enthusiasm and says: "Pride of place will cheerfully and gratefully be given to the Carrel-Dakin procedure." In an analysis of the entire subject he then presents very much the views herein developed. To his teaching and to that of Morgan, Saner and Schlesinger[1] we are greatly indebted. Their writings have been invaluable in helping us to arrive at what we find a most satisfactory working knowledge of this complex subject. They have given a clear-cut conception, largely lacking in the mass of literature which has appeared in the past two years.

The use of dichloramine-T has been given as thorough a study during the seven months as has the hypochlorite solution. It has not proved so efficient. It lacks the very element which makes the hypochlorite solution potent —namely, any appreciable proteolytic power. It will act as a bactericide on wound surfaces, but more than this is needed. Even in this respect it has proved disappointing as compared to the more active chlorinizing agent. Many wounds kept clean on the surface with the hypochlorite promptly showed a higher bacterial count under the use of the dichloramin-T.

In conclusion we desire to emphasize the two points which a study of war conditions has made applicable to our work in a civil hospital: (1) It has enabled us to get a very close coöperation between our forces and those ordinarily fully occupied in labora-

[1] Some Aspects of the Treatment of Infected War Wounds, British Jour. Surg., No. 19, v, 425.

tory work. The practical benefits accruing to the patients have demonstrated to these men that they have an immediate responsibility in applying their knowledge to clinical problems. This responsibility they have accepted with a helpful enthusiasm which, heretofore, we have failed to arouse. Our studies could not have been productive without their aid. One immediate result of this coöperation has been the development by Dr. Stanley Benedict, professor of chemistry in Cornell Medical College, of a simple, cheap and efficient method of preparing Dakin solution. (See Appendix.) To him we are indebted for having always on hand an absolutely reliable, standard product. Any questions as to its correct composition were immediately answered in an authoritive way. (2) We found in the study of traumata, infections, and suppurations a field heretofore little cultivated, rich in interest and yielding a return in actual service rendered to the patients, hardly exceeded by any branch of surgery within our experience.

We are fully satisfied that by applying the teachings of military surgery to these conditions a definite advance has been made in their treatment.

Preparation of Dakin Solution from Liquid Chlorin by the Gravimetric Method

BY STANLEY BENEDICT

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The best theoretical method for the preparation of sodium hypochlorite solution of known strength is to pass a weighed quantity of chlorin gas into a solution of sodium carbonate. The reaction proceeds as follows:

$$Na_2CO_3 + 2Cl = NaClO + NaCl + CO_2$$

Weighing the chlorin used is preferable to attempting its measurement by volume for the following reasons:

1. Greater accuracy, since volume of chlorin gas is subject to change from temperature and atmospheric pressure changes.

2. The apparatus required for weighing the chlorin is less complicated, less readily broken and cheaper than that required for the volume-measurement of chlorin.

3. The process of weighing is more rapid and convenient than measuring the gas.

The following is the procedure for the preparation of 10 liters of Dakin solution by the gravimetric method:

Apparatus and solutions required:

1. A Torsion balance, capacity to 10 pounds, sensitive to about 0.2 gram (cost about $40).
2. Two 1-liter Florence flasks.
3. A Folin or other suitable absorption bulb.
4. A tall form absorption bottle of about 100 c.c. capacity.
5. A 20 per cent. solution of anhydrous sodium carbonate.
6. A 10 per cent. solution of crude caustic soda.
7. A small calcium chloride drying tube.
8. Suitable rubber tubing (a few feet of thick wall tubing).
9. A cylinder of liquid chlorin.

Procedure: The cylinder of chlorin is connected to the calcium chloride tube with rubber tubing. The other end of the tube is connected with a piece of narrow bore, heavy wall tubing about three feet in length. About a foot from the end this tube should reach over the balance, with a suitable support to hold it at about the height of the first absorption flask and so adjusted as to prevent the tube from slipping in either direction. Into one of the Florence flasks is placed 900 c.c. of the 20 per cent. carbonate solution (the solution can be prepared without undue exactness and can be measured in an ordinary graduate). This flask is fitted with a 2-hole rubber-stopper, through one hole of which passes the Folin absorption bulb, bent at right angles at the top. Through the other hole passes a short outlet tube, also bent at right angles. The flask is placed on the balance and the inlet tube connected with the rubber tube from the calcium chloride tube. The outlet tube is connected by means of a short piece of thick-walled tubing to the small inlet tube of the absorption bottle, which should contain about 90 c.c. of 10 per cent. NaOH.

and which is placed on the same pan of the balance with the Florence flask containing the carbonate. (NOTE.—The function of this second absorption bottle is to retain carbon dioxide liberated during the action of the chlorin. Unless this gas is retained it would ultimately be weighed as chlorin.) The second Florence flask (which should have a stopper provided for it) is placed on the other pan of the balance after having been about half-filled with sand or other heavy material. The stopper for this flask is also placed on the pan and water added to the flask until the two flasks counterbalance practically exactly. With a little practice this counterbalancing requires only a moment or two. Weights amounting to exactly 43 grams are then placed on the pan with the second flask and chlorin gas is passed into the first flask until the two flasks come to a balance, *i. e.*, until 43 grams of chlorin have been added to the first flask. The chlorin should be bubbled into the first flask at such a rate that not less than twenty or more than thirty minutes are required for the passage of the 43 grams. After the chlorin has been passed in the flask is disconnected from the inlet tube and from the second absorption bottle and the contents are diluted to 10 liters with tap water, taking care to wash the absorption bulb and the inside of the flask thoroughly during the dilution to ten liters.

NOTE.—The method may be employed to advantage for the preparation of 5 to 20 liters of Dakin solution at one time, changing the constituents used in proportion to the final dilution. The weight of chlorin used is slightly below theoretical, this being accounted for by the loss of a small amount of carbon dioxide in spite of the absorber. About 500 to 700 liters of solution have already been prepared by the above method. Never has a correction in reaction (alkalinity) had to be made, and in only one trial was a correction necessary for the hypochlorite content This latter ranges practically invariably between 0.46 and 0.49 per cent. of NaClO.

THE ROLE OF THE EVACUATION HOSPITAL IN THE CARE OF THE WOUNDED

By DANIEL FISKE JONES, M.D.
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The value of the time element in the treatment of wounds in this war is of such importance it has made imperative the treatment of the wounded within ambulance drive of the front. This would hardly seem to need amplification, yet in talking with many medical officers who have not yet been to France and come in contact with the gas bacillus and streptococcus, its importance and difficulty of accomplishment do not seem to be realized. This in part is due to the emphasis laid on the importance of the various antiseptics by those who have returned after visits to the hospitals in France. They have told us of the wonderful results obtained at La Panne and Compiégne and have made little of the fact that patients in these hospitals are received directly from the front, usually within twelve hours of the time of being wounded.

We were at General Hospital, No. 22, B. E. F., when some of these enthusiastic reports came out and often wished that these observers could visit us and see what the wounded looked like in the base hospitals, about three days after being wounded and with little or no early treatment.

We all appreciate the advantage of early operation in infected abdominal cases, but the importance of time is not so well appreciated in relation to wounds of other parts.

Tarnowski[1] says, "while the research casualty clearing station

[1] Jour. Am. Med. Assn., March 16, 1918.

(British) is not ready to render a final report on the various solutions employed, the results so far tend to prove that the *sine qua non* of success lies, not in the antiseptic used, but in the (early) radical excision of the devitalized tissues."

If one had any doubts as to the value of early and thorough treatment of wounds, those doubts would have been dispelled if he had visited the area with which I was associated. There, ward after ward of a two thousand bed hospital, and hospital after hospital of the same size, was filled with practically nothing but wounds infected with the gas bacillus or streptococcus, and the average time of arrival at the hospital was three days after being wounded.

In the same area was one experimental ward filled with patients who had been brought directly from the front by ambulance and had been operated upon, within twelve hours, by an experienced surgeon under Sir George Makin. These cases were, in addition, treated by the Carrel-Dakin method. About 80 per cent. of the wounds were closed successfully within ten days, while the patients in all the other hospitals were sent to England in from three days to six weeks, with many more wounds than they came with, all discharging pus freely and with no suggestion of bony union in the compound fractures.

If we admit that time is an important factor, it is evident that some scheme must be worked out for the thorough treatment of these cases at the front, for while the base hospitals of which I speak were only forty or fifty miles from the front, the time by ambulance train was from twenty-four to thirty hours.

In looking over the different units, it was evident that the casualty clearing station which corresponds to our evacuation hospital, was the one best suited for development for this work. Bowlby and Wallace[1] say: "The development of the casualty clearing stations has been the most important factor in the creation of a new school of surgery at the front, and it is not too much to say that they have saved many thousands of lives which

[1] Abstracts of War Surgery.

would have been lost but for the surgical opportunities which they have provided. Before the war the casualty clearing station appeared only on paper and as untried units, for they did not exist at the time of the South African War. They were originally called clearing hospitals, and their proposed function was merely to clear the field ambulances and pass the patients on to the base hospitals. Their equipment therefore was only very slight, and their staff of eight officers, including the command officer and the quartermaster, was less than the staff of a field ambulance. They carried 200 stretchers and were supposed to be able to deal with the same number of patients."

The original British force went to France with six of these units, but it was soon discovered that they were to be a very important link. Beds and bedding were first added, then trained nurses, surgical equipment and a special surgeon. These hospitals have been added to in various ways, up to the present time, and in 1916 more than 50 were at work, each with a capacity of from 400 to 1200 wounded.

In 1916 these units were fairly well equipped to care for the wounded in ordinary times, but even then lacked much necessary equipment for good work, especially a sufficient supply of roentgen-ray apparatus. Since 1916 much has been added, but by far the most important change of all has been made in the way of making these units elastic. They are now a nucleus about which a great mobile force of medical units gather during a battle to care for the great number of wounded. It is well known that hospitals of all kinds—evacuation, field, and base—have periods when comparatively little is going on. With the aid of the motor car, operating teams, nurses and orderlies can be collected from the inactive units, in a comparatively few hours, and brought to the sector in which the battle is about to begin or has begun.

Perhaps more important still than these borrowed teams are the mobile units, or auto-chir of the French. These are absolutely complete and independent hospital units, including roentgen-ray apparatus, and from five to ten operating teams, on automobile trucks, which can easily be moved from one sector to another, as

is needed. With operating teams from the base hospitals and inactive evacuation hospitals, operating teams and hospital equipment from the field hospitals and the complete hospital and staff of the mobile units the evacuation hospital becomes a wonderfully elastic and efficient organization.

It is a great satisfaction to know that the United States Medical Service has at least one of these mobile units, most wonderfully and completely equipped, and several more under construction.

The sending of teams from the base hospitals to the evacuation hospitals, while of great benefit to the evacuation hospital, is undoubtedly one of great importance in training surgeons, for they are in this way given an opportunity to see the results of work done at the evacuation hospitals. If in 1915 the men from the casualty clearing stations had been sent to the base hospitals even for a week they would have changed their methods without doubt.

The furnishing of a sufficient number of wards, as to whether they shall be tents or wooden shacks, the supplying of nurses, etc., are details difficult to arrange, which I cannot go into here.

The location of the evacuation hospital is of great importance, for the patients must be brought to them easily and evacuation must take place easily and rapidly. In these days of the motor ambulance it would seem that the placing of the evacuation hospitals would depend somewhat more upon other factors, such as railroad accommodations, avoidance of artillery fire, the avoidance of having to move with every thrust of the enemy and the peace of mind of the patients, rather than upon the close proximity to the front line for the purpose of easy transportation. A distance of fifteen, twenty or even twenty-five miles from the front would make little difference to the wounded after they are once in the ambulance, and the great delay is usually between the trenches and the ambulance. A large number of ambulances would be required, but they are more easily obtained than new evacuation hospitals if they are lost because too close to the lines. Again, ambulances can be drawn from the quiet sectors to help out in busy ones. To offset the disadvantage of the larger

hospitals being placed far back of the lines, small evacuation hospitals can be established close to the lines for the treatment of very urgent cases, as the British do at present.

It will be seen that the evacuation hospital must be a combination of field and base hospital. In location and in the early treatment of the wounded it may be considered a field hospital in size, permanency, equipment, and the work it does it may be considered a base hospital. The combination makes this hospital a difficult one to equip and maintain. To equip it with all that is necessary, to care for the wounded during ordinary times, would be comparatively easy, but to equip it and carry on the work required of it during a battle is the difficult problem.

In spite of all efforts to meet the demand for immediate and thorough treatment of the wounded it must be impossible, in the great battles, to care for all the wounded within the prescribed time of twelve hours, but much can be done to help out in these times by sending cases direct to the base hospitals by ambulance train. Many chest cases, many gutter wounds, all wounds of the soft parts, without fracture, many head injuries which do not open the skull, may be sent direct without doing much harm to the patients.

Before leaving the evacuation hospital in all its glory let us take a look at its work from a base hospital. During the Somme drive, from September to December, 1916, we had the good fortune to be at General Hospital No. 22, of the B. E. F., a very active base hospital, through which 9000 patients passed in three months. It was located between forty and fifty miles from the front, but was between twenty-four and thirty hours by ambulance train from the casualty clearing station. It was kept filled with wounded from the various casualty clearing stations and only rarely a case direct from the front line hospitals. The wounded arrived on an average of three days after being wounded and included all varieties of wounds except the urgent abdominal cases. All cases were infected with the gas bacillus or streptococcus. All, or at least a very large proportion, of the cases had been operated upon at one of the front-line hospitals or a casualty

clearing station. In every convoy from one to five immediate amputations were necessary, while all other wounds, except an occasional rifle or shrapnel ball wound, would have to be opened up wide and fragments of shell and clothing removed. Some cases were already moribund and no operation would be of avail. Knee-joints would come to the hospital with fragments of shell and clothing in them; legs and arms would come to us gangrenous, because a main artery had been tied and the original wound had become infected; head injuries, with or without fragments of shell in the brain, arrived at the base hospital, with meningitis or discharging foul pus. These were the conditions not only in our hospital but in all others in the region, and this was the condition when Bowlby and Wallace state that there were fifty casualty clearing stations with the British forces, well equipped and with a capacity of about 40,000 beds. If this was the condition to be found in other regions, of what value were the casualty clearing stations, and how can these results be improved?

It must be understood that the medical service was working under great stress at this time. The enemy was very active, the British were pushing forward and the country in which the British were fighting was almost entirely without shelter, and was wet and boggy, all of which caused great delay in picking up the wounded on the field and in getting to the casualty clearing station.

Bowlby and Wallace[1] show that out of a series of 200 abdominal cases only 164 arrived at the casualty clearing station within twelve hours, that is, 66, or 33 per cent. arrived so late that they had little chance of recovery because of the elapsed time alone.

Many men were left wounded on the field twenty-four hours, others three or four days before being found. This will account for the septic condition of many, the inability to care for the wounded promptly at the casualty clearing station, because of the great numbers which came in and because the operating teams from the base hospitals and the mobile units were not yet

[1] Abstracts of Surgery.

being used, will account for others, and the lack of equipment, particularly roentgen-ray apparatus, will account for a few others. With all these reasons we still have a large number of septic cases to account for. There are, we believe, two good reasons for these remaining cases:

First, the majority of surgeons at the casualty clearing station had never been at a base hospital to see the result of the work done at the casualty clearing stations. The second, and we believe by far the most important reason of all was, that the casaulty clearing station was considered a front line hospital and had not yet been dignified by a complete staff of experienced surgeons, except for an experienced man to do abdominal work. It is generally admitted that men of ability and experience are needed for abdominal work, but for the other wounds few appreciate that they are necessary.

We have heard of the splendid results obtained at La Panne and Compiégne by the Carrel-Dakin treatment, but few appreciate that this treatment in these hospitals consists not alone in the use of Dakin's solution but in the thorough mechanical cleaning of the wound within twelve hours by that veteran of war surgery, Depage, and by that master of delicate technic Carrel, and men trained by them. It would no doubt be admitted that young and inexperienced men in their places would find great difficulty in getting comparable results.

It is a very strong statement to make, but we believe that the value of the casualty clearing stations in 1916 was almost nullified, in fact much harm was done by them, except in abdominal cases, because of inexperienced surgeons. Almost every case which came to the base hospital had been operated upon, some necessarily, at a division or corps hospital or a casualty clearing station. This operation, which was incomplete in nearly all cases, delayed the arrival at the base hospital where there was an experienced staff, by one or more days, making the average time of arrival there about three days after being wounded. The wounds were then so infected that another extensive operation, with many incisions and removal of shell fragments and pieces of clothing,

was necessary. Without the intervention of the casualty clearing station the wounded would have arrived at the base hospital in from twenty-four to forty-eight hours, a considerable saving of important time. As an excuse for this statement I may say that it was made to the representative of the Director-General and the Director-General of the B. E. F. in France in October, 1916.

It will be seen therefore that to make the evacuation hospital most effective the patient should arrive within twelve hours, and this factor it is impossible to control because of the enemy and the character of the country, but more important still the staff must be made up of surgeons of ability and experience.

There is an effort to keep the experienced men in our base hospitals down to 40 per cent. of the staff, which is important; but of still greater importance is the keeping of the experienced men who are to work at the evacuation hospitals up to 100 per cent. From experience at a base hospital I am convinced that the evacuation hospitals and mobile units should first be equipped with staffs of surgeons of well-known ability and experience, after which the base hospitals should receive their 40 per cent. of experienced surgeons if it is possible to get them.

It has been said that the country cannot afford to place such a large proportion of experienced men in these hospitals because of the danger, but at least it could be done until it has been proved to cause too great a loss of these men. It has been said that experienced surgeons will be needed in large numbers in the base and reconstruction hospitals, but if they are used in the evacuation hospitals there will be less demand for them in these hospitals.

That the number of men needed in the evacuation hospitals will be large cannot be doubted. Major Dehelly told me that he could properly operate upon but 20 cases in twenty-four hours. Tarnowsky[1] states that a team in a French auto-chir had operated upon 67 cases in twenty-four hours, but it is probable that the average team could care for nearer 20 than 67 cases, if the work

[1] Review of War Surgery and Medicine, March, 1918.

is thoroughly done, and it is useless to waste time doing any operation unless it is thoroughly done.

It must be difficult, I am sure, for any who have not seen the wounds of this war, at a base hospital in France, to appreciate in any way the terrible infections seen there.

The deaths, the disabilities, the suffering and enormous loss of time caused by sepsis, which in turn is caused largely by delay and inefficient operations, are impossible to compute. If you will follow in your minds the course of a patient with an infected compound thigh fracture, with splintering of several inches of femur, and then the course of a similar case properly cleaned and the wound immediately closed, or closed in ten days, then multiply the difference by many thousands, you will get a slight idea of the value of the evacuation hospitals, when properly equipped and with permanent staffs of surgeons of known ability and experience aided by mobile units and operating teams from various base and field hospitals, and inactive evacuation hospitals.

SURGICAL TREATMENT OF WAR WOUNDS

By C. L. GIBSON, M.D.
NEW YORK

As the present war has brought out entirely new military problems, so has the preconceived notion of treatment of wounds required entire revision. The wounds inflicted today are by new forms of projectiles, the supply of which in contrast to former methods is absolutely lavish. Deep trench warfare has rendered the soldier a filthy and constantly contaminated person, particularly the trenches of Flanders and Northern France, dug in soil which for centuries has been saturated with manure and other fertile sources of infection.

The treatment of war wounds is a highly specialized branch of surgery, and the rules of civil practice apply hardly, if at all, at the front. Moreover, we have to deal with a different kind of individual than in civil practice. In the latter phase the factory hand who is badly hurt will, however, have been in good condition immediately prior to his injury, will have come from clean surroundings, his person and clothing will be relatively uncontaminated, will recently have had food and drink and will not have been exposed unduly, and perhaps for a long time, to the effects of cold and wet. When injured some form of competent relief is almost immediately at hand and transportation to a well-equipped hospital usually speedy and comfortable. Moreover, the treatment at this institution can usually be given promptly. The elements of fear and anxiety and the strain of prolonged expectation of injury are likewise absent.

The wounded soldier will probably have been subjected to

harassing conditions of warfare. His injuries may be multiple. It may be some time before he is picked up and in addition to the other conditions he may be deprived of food and drink, especially the latter, for a long period of time. The journey out of the trenches is long, tedious, hazardous and may greatly add to the patient's shock. It is therefore obvious that special training for proper treatment of such cases must be obtained and must be derived from practical experience at the front and cannot be replaced by theory.

The three main factors of wounds are (1) shock, (2) hemorrhage and (3) sepsis. The latter element in this war is almost 100 per cent. possibility. Soon after the outbreak of hostilities it was generally conceded that this constant element of sepsis must be combated by something more than the usual line of treatment for every-day trauma.

In addition to laying wounds freely open, three things quickly developed, namely, the importance of early treatment, no matter what kind, the bad effects of leaving projectiles and other foreign bodies in the wounds, and the necessity of actual destruction of the bacteria. The first has been met by constantly moving up better organized lines of relief closer and closer to the front. At the present time it is aimed, it possible, to do such thorough and early surgery close to the lines that relatively little remains to be done at the rear. It becomes obvious that even by modern antiseptics no foreign body, usually contaminated as it is, could be sterilized by any method, no matter how efficient or thorough.

Credit is due to Dr. Carrel and his co-workers who have demonstrated that although bacteria can be very efficiently combated in the tissues at almost any stage, these methods fail in the presence of foreign bodies. Also proceeding on these lines it becomes evident that tissues which were damaged made favorable places for bacteria and were of themselves a source of danger.

It was pretty clearly demonstrated in 1916 by Carrel and some of those who followed his methods accurately, like Depage at La Panne, that the Carrel method, providing the patient came

under treatment early and was submitted to thorough operation, namely, free excision of the tract of the missile and the removal of all foreign bodies, acted as an efficient prophylaxis against infection.

It will be appreciated that even with the demonstrated efficiency of chemical sterilization, good surgery applied at a very early stage was almost a *sine qua non*, and, in fact, chemical sterilization became an adjuvant and not a substitute for good surgery.

The Carrel method is well known or should be. In order to be efficienti must be done rightly. To be done rightly requires a series of steps necessitating infinite care and continued treatment under the same conditions. It is quite impossible, under the unusual circumstances of warfare, to give the great bulk of wounded men who come to hospitals near the lines in large numbers, and in a short space of time, such treatment.

The present-day generally accepted method as practised by the Allies on the Western Front aims at prophylaxis of wound infection by a method which, in some ways, is simple, and if it can be carried out efficiently gives such good results as to minimize the necessity of complicated or prolonged after-treatment. The present-day method aims at the radical excision of all open wounds, removal so far as feasible of all foreign bodies, be they what they may, and the complete removal of all bruised, infiltrated, damaged or "shocked" tissue. Operations done on this principle and done thoroughly by highly competent surgeons, with a large experience in this particualr line of work, give the surest guarantee against the development of all forms of sepsis, particularly the dreaded gas gangrene.

It has been my privilege to observe the workings of this method in both the British and French Armies. The principles in both armies are about the same, varying only in minor degrees and particularly in those of organization. This radical excision of wounds is usually done in the British Army in the so-called "Casualty Clearing Station," which will be situated ordinarily from five to ten miles back of the lines.

The wounded soldier is first brought to a dugout back of the trenches where first aid is administered and then to the dressing station, say one to three miles back of the lines at the end of the communication trenches, at a place where ambulances, motor or horse, can come with comparative safety.

The casualty clearing stations are mostly under canvas. Their units can be multiplied readily. In so-called "peace" times they have approximately 200 beds and a medical staff of 6, which can be increased to 800 or more beds and a medical staff of approximately 25. The patient is brought in carefully warmed ambulances, usually under a sufficient amount of anodyne to diminish shock, both physical and psychical. He is carefully unloaded in a waiting room which is well warmed and protected from drafts and passes into an examining room when his wound and condition are carefully investigated by a highly trained and competent physician who decides on the various steps he will need.

A very few cases of apparently simple conditions may be transferred directly to a base hospital from the casualty clearing station, but the majority of the cases will need some form of operative procedure. The minor cases which form a large group are handled by a special surgeon and a special department and their conditions taken care of either with or without a local anesthetic or with "laughing gas." A certain group of cases may require operation, but their conditions are so precarious that it must be postponed until the patient can be brought back into better condition. These are sent to a special department, called the Resuscitation Ward, where they receive special attention and where there are special resources. Emphasis is placed on heat, particularly heat as given in hot-air baths. The administration of fluid is important as the dehydration of these patients add to the gravity of their conditions. When these patients seem in a condition to stand operation they are returned to the "pre op room," where all the patients await their turn to go into the operating room. Patients requiring an operation which is perhaps not very urgent may wait in the "pre op room" several hours, giving precedence to the more urgent cases. The patient is still kept very

warm and is cleaned up to the extent his condition will allow. Badly shocked patients are little disturbed, their clothing being removed on the operating table when they are anesthetized. When the patient comes to the operating theater he is operated on by the surgeon, the head of the surgical team.

A surgical team consists of an operating surgeon of recognized capacity, a physician who acts as anesthetist and at other times does work around the hospital, particularly in the after-care of patients, a nursing sister who acts as assistant surgeon and instrument nurse and a trained orderly. These teams, which generally have been working together for many months, make for the highest efficiency and organization. These teams now bring with them a portable operating table and a supply of routine instruments. This system allows the localization of both personnel and apparatus when it is needed and under most economical management.

The English group their major operating in one single operating theater. This system makes for distinct economy of space and equipment and I have never seen any evidence of confusion arising from this method. (This plan is in contrast to the French system in which each surgeon has his own cramped and very small operating room.) The patients are, for the most part, given a general anesthetic, having already received in transit a generous supply of morphin. The skin is disinfected by mechanical cleansing with soap and water and 5 per cent. alcoholic picric acid solution, which is very efficient and non-irritating.

The surgeon is guided also in some cases by roentgen-ray pictures. In times of greater activity many roentgen-ray examinations have to be omitted and it is only in "peace" times that an appreciable amount of plates can be made, the patient having to be examined under the fluoroscope. The French have developed their fluoroscopy and other means of foreign body localization to perhaps a higher degree than the British and seemed supplied with rather better material resources.

The operation having been conducted along the lines already stated, it is customary in both armies to swab out the wound

with some form of antiseptic, the most popular being ether; why, I do not know. Rather small and superficial lesions can be sewed up like ordinary operative wounds, but in the British Army the deeper wounds are more likely to be packed with gauze soaked in paraffin oil containing some form of antispetic. One per cent. iodoform seems to be the most popular.

These patients are then returned to the wards, most of them to be evacuated on the first hospital train if their condition permits. While it is the aim of the casualty clearing station to evacuate patients for military and psychical reasons as soon as possible, it is generally planned to keep head, chest and abdominal cases one week.

At the base, wounds are redressed and packing removed at a varying time, usually on the average from five to six days. It is stated that the condition of the wound then allows of early suturing in layers and that the results are generally good. I have no means of corroborating this statement from personal experience, but I believe it to be true.

In the French Army primary suture of these wounds is done rather more freely than in similar institutions of the British Army and considerable reliance is placed on cultures; but if the culture shows a streptococcus or Bacillus perfringens the wound is immediately laid wide open and treatment of the open wound is instituted, either by the Carrel method or some other method as the operator practices.

With the French Army this means a somewhat closer relation between the H. O. E. (Evacuation Hospital) and the bases. Moreover, the French, so far as possible, like to have the base hospitals in which the work is to be continued only a relatively short distance away. It is the belief of the best surgical minds in France that a hospital situated at a point farther away than 40 to 60 km. does not really perform the function of an acute hospital but rather that of a convalescent home.

I deem it inexpedient to go further into the treatment of war wounds when they have been transferred in the later stages to the base hospital. The farther away from the front and the longer

the time that elapses from the injury, more do the conditions resemble those of civil practice, and it is not my purpose to enter into consideration of these.

I recommend a pamphlet entitled "Surgical Treatment of War Wounds, in the Medical Units of the Third Army, British Expeditionary Force, with Special Reference to Casualty Clearing Stations, February, 1917," which gives thoroughly and more in detail some of the points I have touched on in this article. I append two articles from this pamphlet:

Reception and Distribution of Cases in a Casualty Clearing Station

BY CAPTAIN E. W. N. WOOLER, R. A. M. C.

Reception of Cases. On arrival, patients are sent to the reception room or rooms. If only one is available it is partitioned so that lying cases go to one side of the partition, walking cases to the other. It is better, however, to have separate huts for each class. The names are entered in admission and discharge books. They are then sent to separate dressing rooms, one for lying cases and one for sitting cases. In case of a big rush, accommodations for 100 to 200 cases or more should be available near the reception huts, where patients may be put before their names can be taken. This prevents the ambulance cars being held up unduly.

Dressing Room. The dressing room for lying cases should have accommodation for about 8 cases on folding tables at one time. These wooden tables should be substantial, and are made in such a way that when the stretchers are placed on them the poles of the stretchers fall over the sides of the tables and so facilitate the dressing of patients. They are arranged in two rows of four, each of the two medical officers on duty dealing with the cases in one row.

Annexe. A part of each dressing room is screened off to form an annexe for the performance of minor operations.

Distribution from Dressing Rooms. A. *Lying Cases.* All cases fit to be evacuated to the base forthwith are sent to marquees or huts, where they are fed and otherwise attended to until a train is available.

The following is a rough classification of those cases which are detained:

1. *Abdominal Cases.* Abdominal cases in which penetration of the abdomen is suspected. Wounds of the chest, especially of the lower part, of the lumbar region, sacrum or buttocks should always lead one to examine carefully for abdominal symptoms.

2. *Chest Cases.* Chest cases in which penetration of the chest is evident from the urgent symptoms present. Other cases in which penetration is merely suspected or very doubtful can be evacuated at once.

3. *Head Cases.* A large proportion of head cases, namely, those with "compression" symptoms or which show undoubted evidence of injury to the brain, especially if brain matter is exuding from the wound.

4. *Gas Gangrene.* Cases of gas-infected or suspected gas-infected wounds, *e. g.*, a limb showing tension even though there is no evidence of actual gas formation.

5. *Femur.* Cases of compound fracture of the femur and all other fractures which cannot be thoroughly cleaned up and efficiently splinted in the dressing room.

6. *Oozing.* Cases of deep-seated hemorrhage, even though the vessel concerned is not a large one. Many men arrive in an exsanguine condition, owing to their wounds having oozed steadily all the way down; but the appearance of the wound at previous dressings has not led each succeeding M. O. to attach much importance to it. By the time the man arrives at the casualty clearing station he has lost quite a considerable amount of blood.

7. *Shock, External Hemorrhage.* All cases suffering from shock, external hemorrhage, etc., unfit for evacuation, whether cases of above types or not, *e. g.*, cases of multiple wounds.

8. *Flesh Wounds.* A variety of flesh wounds which do not admit of immediate evacuation, or which cannot be dealt with in

the operating annexe, *e. g.*, a limb showing a large wound (but no fracture), with considerable destruction of muscle tissue. The extent of operation required may be beyond the limits of the annexe with gas anesthesia, and the case should therefore be sent to the theater.

Disposal of Cases. 1. *Abdominal Cases*, if fit for immediate operation, are sent to the preoperation room for preparation. If unfit for operation at the time of admission, they are sent to the ward set apart for resuscitation of cases, or to the special abdominal ward.

2. *Chest Cases.* Chest cases are sent to wards set apart for them.

3. *Head Cases.* Head cases are sent to the preoperation room.

4. *Gas-infected Wounds.* Cases of gas-infected wounds are sent to the preoperation room.

5. *Compound Fracture of the Femur.* These cases as well as some other fractures are sent to the preoperation room.

6. *Hemorrhage.* Cases of deep-seated hemorrhage are sent to the preoperation room.

7. *Flesh Wounds.* Cases of flesh wounds are sent to the preoperation room.

8. *Shock, etc.* Cases suffering from shock or effects of severe hemorrhage are sent to the resuscitation wards.

The M. O. in charge of these wards (preoperation, chest, and resuscitation) notifies the surgeon-in-charge as soon as a case is fit for operation or develops symptoms necessitating immediate operation. Cases suffering from active hemorrhage which cannot be dealt with in the dressing room should be notified to the surgeon-in-charge of the theater at once.

General Principles Guiding the M. O. in Deciding Whether to Evacuate or Detain a Case. 1. If there is any tension, edema or inflammation around the wound.

2. The presence of a thin brownish discharge which exudes under pressure.

3. An odor "fecal" in character.

4. If the wound is one in which gas-infection is likely to develop

if left alone, *e. g.*, a small wound of entrance which has become wholly or partially occluded and in which there is much laceration of deeper parts.

If the condition of the wound is satisfactory and presents none of these appearances or if its condition can be dealt with in the operating annexe, such a case may be evacuated. The presence of any one or more of these phenomena, which is outside the scope of the annexe, should lead to the case being detained and sent to the theater.

5. Some cases which have been lying out for several days and are suffering from the effects of exposure and starvation should be detained, although their wounds might admit of their being evacuated.

6. Finally, attention must be paid to the number of cases accumulating for the theater, and should that number become large—say 40 or over—cases may have to be evacuated which would otherwise, for the sake of safety, be sent to the theater. Their wounds should be opened up by well-placed incisions. This can sometimes be done without anesthesia, *e. g.*, in a transverse wound, by incision on the distal side where the nerve supply has been cut off.

Annexe to Dressing Room. This consists of a part of the dressing room, screened off and fitted up for the performance of minor operations under gas or ethyl chloride anesthesia. By having such an annexe the theater, which is always working at high pressure, is relieved of a certain amount of operative work, and the routine work of the dressing room is thus interfered with less than if operations are carried out in it. There is also the additional advantage that other men do not see anesthetics being given nor operations being carried out.

Type of Case and Extent of Operation Suitable for Operating Annexe. 1. Cases of gunshot wound in which a foreign body can either be felt or seen projecting beneath the skin and which can be easily removed. When, *e. g.*, abdomen or joint is implicated, such cases *must* go to the theater.

2. Cases of gunshot wound in which enlargement of the wound will afford better drainage and lessen the risk of the wound becoming occluded and developing a gas infection.

3. "Simple," in the strict sense of the term, as opposed to "compound" fractures, *e. g.*, of the femur, for application of a Thomas splint.

4. All cases of compound fracture which require redressing and reapplication of the same or another type of splint, but which do not call for immediate theater treatment. This only applies to cases in which the wound is freely open and there is no great comminution of bone as all severe compound fractures should be sent to the theater.

5. Lastly, if the pressure on the theater is great, a few cases in which a limb is practically severed may be dealt with and amputation completed, provided other considerations, such as the general condition of the patient, admit of this procedure. As the stumps in most of these cases will require extensive trimming, amputation is not recommended for the annexe except under conditions of extreme pressure.

Following the administration of gas, etc., cases should be detained in the annexe for a quarter of an hour before being sent to the evacuation shelters. This principle is of more importance with reference to cases which have received theater treatment and are suitable for evacuations.

Ordinary Cases Which Should be "Taken Down" without Fail in the Dressing Room. 1. When dressings are soaked with blood.

2. When splints are not applied properly or when unsuitable splints have been used.

3. When swelling has occurred, particularly in distal parts of limbs, which may indicate "concealed" hemorrhage.

4. When genuine complaints of much pain are made, especially if of recent development, possibly indicating a gas infection.

5. Every case of gunshot wound of the head. Many cases with severe fracture and with brain matter exuding *walk* into the dressing room.

Scheme of Labeling. In the distribution of lying cases from the dressing room it is necessary to employ some scheme of labeling in order to avoid confusion. The larger proportion of cases will be found fit for evacuation (probably about three-quarters), and these are marked with a red label bearing the letter "E." Other cases are labeled with a label, the color differing according to whether the case is intended for chest wards, pre-operation room or resuscitation wards, etc., each label bearing the name of the ward in addition. By combining the name of ward with a distinctive color, there should be no mistake on the part of the stretcher-bearers as to the allocation of a case. Except in the case of red "E" labels, the numbers of which must be unlimited, the number of other labels for chest and resuscitation wards should correspond to the number of beds available in each ward. The labels are sent back to the dressing rooms as the patients are evacuated and are kept there in a special box for each sort. In this way the M. O. knows when such a ward is full. By checking the number of labels issued for the pre-operation room an indication of the amount of work awaiting the theater staff can be obtained.

Walking Cases. In dealing with "walking cases" the same general principles are followed as with the lying cases and the same scheme of labeling is employed.

A small operating annexe for minor operations is also screened off for the same type of case and with the same scope of operation as in the lying cases.

Cases for Evacuation from the Dressing Rooms are sent, "sitters" to a large shelter, lying cases to special marquees in the Evacuation Department, where they can be fed and otherwise attended to. Marquees are available also where sitting cases can go and lie down if they wish to, pending the time for their evacuation by train. If there is much delay, many of these cases will require dressing.

The Preoperation Room. The preoperation room should be capable of holding at least 30 to 50 cases on stretchers. Every case for operation, except those mentioned above for special

wards, passes through this room before going to the theater, and is undressed, shaved, etc. In this way the wards are spared a great deal of unnecessary work, as no case for operation, unless specially collapsed, etc., is taken to any ward until it leaves the theater. In addition the patients benefit by remaining on the stretchers until they are put on the table, and have not to be lifted from stretcher to bed, or *vice versa*.

Some Impressions Gathered in the Dressing Room. *Question of Frequency of Dressing.* A very large number of both lying and walking cases have been brought in which have been dressed at the regimental aid post, advanced dressing station, main dressing station, and, in some cases, finally at the corps dressing station, before reaching the casualty clearing station. On an average these dressings have been done during a period of six to twelve hours. So far as the walking cases are concerned, this appears a waste of time and of dressing material, and in lying cases, especially those severely wounded, is, in addition of very doubtful value from the point of view of the patient.

In order to lighten the work at a casualty clearing station it would be well to develop the work at main dressing stations in a more specialized way, *e. g.*, by having an experienced officer to select cases, serious ones, including all fractures, not requiring immediate attention, to be sent on at once to the casualty clearing station; lighter cases, likely to be able to travel to the base, to be carefully dressed and labeled in some way to indicate that they need not be dressed again at the casualty clearing station, whether labeled in this manner or not. It will be made evident, from the papers which are to be read, what points require special attention from M. O. S. in field ambulances, etc.

In a general way the rule should hold that no dressing should be changed unless there is some definite indication for it.

The Arrangement of Work When Two or More Casualty Clearing Stations are Working in Conjunction. 1. *Each May Be on Duty for Twenty-four Hours at a Time.* This is most practicable in quiet times, but during offensive ones the casualty clearing station alone may not be able to deal with all the

cases which may arrive in that period; and, again, it frequently happens that under this scheme one casualty clearing station is worked very hard for one period of twenty-four hours while the other is comparatively quiet in the succeeding twenty-four hours. Lastly, during a period of this length, cases for operation accumulate and many have to wait even until next day before they receive attention. The danger of gas gangrene developing under this system is evident.

2. *Each casualty clearing station* receives a definite number of cases (*e. g.*, 200) and is then relieved by the other. The disadvantages of this scheme are twofold. In the first place the receipt of 200 cases may not be any indication of the amount of work which has to be done. For instance, three-quarters of the 200 may be walking cases, and therefore the amount of operative work involved is light compared with that which may fall to the lot of the other casualty clearing station should their 200 be composed of a large proportion of lying cases. The danger of gas gangrene involved in the accumulation of cases and consequent delay in treatment is almost as great in this scheme as in the first.

3. *Each casualty clearing station* received a definite number of cars alternately (*e. g.*, six cars).

This scheme appears to have none of the disadvantages of the other two. The danger of gas gangrene through delay in treatment is greatly reduced and the work is divided evenly between the two units. A disadvantage may lie in the fact that both casualty clearing stations will be more or less on duty continuously, owing to the small number of cars taken by each, and therefore will never have a rest for long. But it is upon this small number that the efficiency of the scheme depends.

Conclusion. Such is the scheme I would recommend for the reception and distribution of cases, based on three months' experience of dealing with large numbers. The whole basis of the scheme depends upon one main factor—that of deciding in the dressing rooms what is to be done with each case as opposed to any other scheme whereby such decision is arrived at in the wards.

Some Principles of Treatment of Gunshot Wounds

BY CAPTAIN C. H. UPCOTT, R. A. M. C.

After two and a half years of war there is still great divergence of opinion on the subject of wound treatment. This is partly due to the fact that military necessities make it impossible for any one man to have cases under observation from the time when the first surgical treatment is undertaken until complete recovery. Many men have written lauding this or that form of treatment, but their observations refer only to a certain period in the history of a wound, and they are generally concerned with the powers of some particular chemical application to hasten the healing process. This quest of the healing balm continues, and, I think, obscures the one common point where all agree—the need for free enlargement of the wound. It is of this exteriorization of wounds that I wish to speak.

It must be understood that my remarks are confined to the work of a casualty clearing station, I have no other experience. I have been guided by the behavior of wounds during the few days the patients have remained in the casualty clearing station and by occasional reports from the base on the later progress of cases.

Most cases arrive at a casualty clearing station between six and twenty-four hours after the infliction of the wound, and, provided the patient's general condition permits of it, the sooner the wound is attended to the better. This proviso as to the condition of the patient raises one of the most difficult problems with which we have to deal. A patient arrives profoundly shocked by his wounds, the cold, and the superadded trauma of the journey. The usual methods for treating shock are applied: warmth, fluids, rest and the alleviation of pain.

Recently transfusion of whole blood has been widely advocated. While in some cases the immediate revivifying effect of this procedure is striking, in many the benefit appears to be no more than could be attributed to the bulk of fluid injected. In cases suffering

from combined shock and hemorrhage it may be that the blood introduced merely goes to fill the venous pool of the relaxed abdominal vessels. Tight bandaging of the limbs or abdomen is always applicable and should be used in conjunction with transfusion. Apart from blood transfusion the subcutaneous or rectal infusion of saline or glucose remains our chief stand-by in the ward treatment of severe shock. The glucose issued in the form of powder appears to be infected with moulds and solutions made from it soon become turbid, even after sterilization. Indolent abscesses sometimes occur at the site of subcutaneous glucose solution, which may perhaps be attributed to this cause. In the early stages of anaërobic infection the intravenous infusion of sodium bicarbonate is of great value. As a stimulant in these cases a hypodermic injection of 10 minims of a 10 per cent. solution of camphor in olive oil should be given and repeated if necessary.

After a few hours there may be a slight improvement in the patient's general condition; then the symptoms of shock merge into those of an overwhelming toxemia suggestive of "acid intoxication." The pallor becomes more marked, the breathing more shallow and often sighing, the feeble pulse, formerly imperceptible, becomes increasingly rapid, while the temperature remains low. The patient often vomits; his mind is alert, but there is little complaint of pain. These are the early signs of deeply spreading anaërobic infection, so liable to occur in wounds of the buttock or thigh, and unless an operation is performed promptly the patient will die. The difficulty lies in choosing the moment to stand an operation and before he has been weakened by the toxemia. I am accustomed to rely chiefly on the character of the pulse; as soon as it can be felt at the wrist a one- to two-hourly record of its rate should be kept, and if this shows a progressive speeding up you have an urgent indication for operation.

It is well to bear constantly in mind the state of affairs existing in a gunshot wound, and the objects to be attained by operation. A missile passing through a limb dissipates a considerable amount of its energy in the tissues; they are struck a terrific blow and

the greater the resistance they offer the more energy will the projectile lose in its flight. When the resistance is enough to arrest, for example, a bullet, it is obvious that all the energy of the missile is spent in the body. It does not follow, however, that the tissue injury caused by a lodging wound is greater than that from a traversing wound; the special gravity of lodging wounds depends on other factors. Given an equal resistance to its passage, the higher the velocity of the projectile, the greater the damage inflicted on the tissues. And this damage is most limited to the track of the missile; it imparts its momentum to everything in its line of flight, so that a radiating area of vibration is set up destructive to cellular life. If the tissues vary in density, the more compact will be driven through the more yielding, with a shattering effect.

This is the first point of importance; the immediate destructive effect of a projectile is not limited to its path.

The second point is that practically every wound is permeated with foreign material bearing aërobic and anaërobic organisms, and some of the latter are capable of thriving in the devitalized tissues among which they are sown.

The object to be attained by operation is a widely open wound, from whose surfaces all foreign matter and dead tissue have been removed.

Types of Wounds. The types of wounds are so manifold that any classification is difficult, but they may be placed in three groups, to provide headings for the discussion of treatment.

1. *Simple Perforating Wounds in Which the Track is of about the Same Diameter as the Skin Aperture.* An example of this group is a bullet traversing at long range the soft tissues of a limb. Entry and exit are small and the damage to muscle is slight.

The majority of these wounds require no operative treatment, or, at most, excision of skin and fascia. Depending probably on the state of the muscle as regards contraction at the moment of impact, small entry and exit wounds are sometimes accompanied by great destruction of muscle; such cases belong to group 3.

Wounds caused by shrapnel balls have certain peculiar features.

Here you have a smooth spherical projectile of low velocity. Having penetrated the skin, its smooth rounded surface enables it easily to find a passage through the muscles, often without causing much surrounding disturbance, but its velocity is so low that it is very frequently held up on meeting tissue of greater resistance. Indeed, it is remarkable how often shrapnel balls are found lodged beneath the skin after having perforated the body or a limb. If the ball and other foreign material are removed, and the entry wound excised, the track does not often cause trouble, although one would think that the wad of clothing carried in ahead of the ball would give rise to serious infection.

2. *Wound in Which the Destruction of Skin and Superficial Tissues is of Greater Extent than the Destruction of Deeper Tissues.* In such wounds as these (gutter wounds, explosive exits, superficial lacerations, avulsions) the wound is more or less exteriorized and all that is required is the excision of all the damaged tissue, in order to attain the ideal of an open wound with a living, uninfected surface.

If this can be assured, the new wound may be closed by primary suture, but unless one can be absolutely certain that the whole of the original wound surface and underlying "shocked" tissues have been removed without infecting the new wound, suture should not be attempted.

3. *Wounds in Which the Skin Aperture is Small in Relation to the Extent of Damage Inflicted on Deeper Structures.* Such wounds may be divided in: (*a*) lodging wounds; (*b*) traversing wounds.

This group includes the majority of wounds; and, apart from injury to important structures, these are the wounds that most urgently call for surgical treatment.

Technic. 1. *Sterilization of the Skin.* Hairy parts should be shaved. If the skin is heavily caked with mud a scrub with soap and water is advisable; in most cases that may be omitted. Cleanse the skin by rubbing with swabs, wet with an antiseptic, such as Dakin's fluid or eusol, for two or three minutes; follow by rubbing with methylated spirit for one minute. During this process the surface of the wound should be covered with an absorbent swab, so that its discharge may not escape and soil

the skin. With a pair of forceps, pack the wound with gauze dipped in 5 per cent. alcohol solution of picric acid (or 10 per cent. iodin).

In the case of a wound of group 3 this allows one to ascertain the direction of the track, a search that is often aided by moving the limb in different directions.

Finally, paint the skin with the picric solution and allow to dry while the towels are being placed in position. I have found that skin treated thus can be rendered sterile. The process may often be carried out during the induction of anesthesia. Hurry and lack of method in cleaning the skin will result in failure to achieve sterility.

2. *Excision of Gutter Wound (Group 2).* The raw surface of the wound is dried and repacked with gauze; it is then completely encircled by an elliptical incision, which should not be less than one-fourth inch from the edges of the wound. It is advisable to complete one side of the ellipse first, cutting deeply through skin and fascia together, and then deepening the cut rapidly until it has reached beneath the deepest part of the wound. This incision is then packed with gauze while the other half of the ellipse is made, so cutting out a wedge of tissue enclosing the wound and not opening into it at any part. The use of a finger in the wound sometimes enables one to cut clear of pockets which would otherwise be opened. If this be done the same finger should be kept in the wound until the excision is completed; it is then disinfected or the glove changed. All bledding is carefully stopped and the wound closed with silkworm-gut sutures, which should just emerge in the depth of the wound as they cross from side to side. Gum mastic varnish, or better, "aëroplane dope," makes a good dressing, and the limb should be firmly bandaged to prevent effusion. If the original wound is opened into at any part during the operation, primary suture should not be done, but the edges may be lightly drawn together over a salt pack or the wound may be left open and sterilized by the Carrel-Dakin method.

3. *Excision of Traversing Wound with Explosive Exit (Group 2).* Pack the wound firmly with gauze. Enter the knife vertically

not less than one-quarter inch from the edge of the wound, and keeping the blade parallel with the sides of the wound, cut all the way around it, deepen the incision if needed until the apex of the wound is reached, thus making a cone-shaped excision of the wound. Dressing may be either a small central tube to the track of the missile surrounded by salt pack or by Carrel-Dakin.

4. *Tunnel Wounds* (*Group* 3). Draw a strip of gauze through the tunnel and connect the entrance and exit wounds by an incision, cutting down on to the gauze, discard the soiled knife, and excise the wound as in 2. Narrow tunnel wounds should not have a rubber drainage tube drawn through them. This only blocks discharge, and if near a bloodvessel it is liable to cause ulceration of its walls.

5. *Traversing Shell Wounds* (*Group* 3). Entry and exit should be excised by elliptical incisions. Usually it is unnecessary to excise more than one-quarter inch of skin around the wound. As a general rule the area of skin excised varies inversely with the skill of the surgeon. In doing this the knife should be plunged through the skin parallel to the track of the missile and an attempt made to excise the tissues around the wound to the depth of the knife blade in one piece. The crushed muscle and aponeurosis in the deeper parts of the wound are seized with tissue forceps and cleanly excised. If sufficient access is not provided by the original wound excision the ends of the ellipse should be prolonged, so that the sides of the wound may be retracted. It is well to remember that prolonged and forcible retraction of muscle is liable to crush its tender fibers and render them a prey to saprophytes in the wound. The need for powerful retraction may be avoided by the use of free incisions. In dealing with the deeper parts of the wound it is to be remembered that the gravest danger arises from infection with gas-producing bacilli, which grow most readily in dead and dying muscle. The following points are important:

1. If a muscle is deprived of its blood supply it will not bleed when cut and will probably die.

2. A dead muscle will neither contract nor bleed when cut.

3. A muscle in the first stages of invasion by anaërobes (pos-

sibly when poisoned by toxine) loses its normal resilience and has a peculiar brick red color.

4. In the later stages of invasion the muscle becomes crepitant and exudes a dark reddish-brown foul-smelling fluid.

Taking singly the most important of these signs is absence of bleeding on section. A muscle may fail to contract when cut so that if this sign is present alone the muscle need not be excised.

6. *Lodging Shell Wounds* (*Group* 3). These are to be dealt with on the same lines as 5 (traversing shell wounds), with the addition that every effort should be made to find and remove the shell fragment and any particles of clothing carried in with it. To this end exploration by sight is more valuable than by the sense of touch alone, whether roentgen-ray localization has been done or not. In these cases it is sometimes difficult to find the track of the missile. If the skin and fascial wound be excised and then the limb be moved, so that the muscles and skin assume different relative positions, the track will become visible and its direction may be gently explored with the finger and excised. In cases in which the metal fragment is lodged among pieces of bone in positions where the wound cannot be opened up have found the Mackenzie-Davidson telephone probe of great service.

Lodging wounds often need a counter incision, either for the purpose of removing the projectile or to provide drainage. The objection to dependent drainage openings if the Carrel-Dakin treatment is to be adopted must, however, be borne in mind.

7. *Multiple Wounds.* These deserve separate mention on account of their frequency and by reason of the special problems they present. The condition of the patient often will not allow one to deal with each wound as thoroughly as could be wished. The first thing to do is to determine the general direction of the projectiles. A search will generally reveal a graze, a gutter or tunnel wound, giving a clue to the course of the others. It then remains to decide which wounds should be first dealt with. Excluding fractures or penetration of the body cavities, lodging wounds of the buttocks, thighs, calves, shoulders and root or the neck should receive preference. If "time" presses, other wounds

may be simply laid open by an assistant, and a salt tablet wrapped in wet gauze laid loosely in each.

Hemostasis. At the conclusion of all these operations great care should be devoted to hemostasis, for pools of blood allowed to accumulate in the corners of the wound favor the progress of sepsis. Seeing that these wounds are accompanied by much crushing of tissue a plentiful supply of thrombokinase will be present, and once the larger vessels are secured, oozing may be stopped by pressure.

Local Rest. Local rest to the injured part is to be secured by firm dressings—and in this respect the salt pack is valuable—or by splints. The use of supporting splints should not be confined to fractures and joint injuries. Further, wounded muscles which have a large excursion on movement of neighboring joints, should be immobilized by fixing those joints.

After-treatment. In regard to the care of a wound after operation; although I know that sterility may be procured by the strict application of Carrel's methods, I am equally certain that these methods are not feasible during a heavy rush of work at a casualty clearing station, however satisfactory they may be in "peace" times.

I believe that for the majority of wounds, after correct operative treatment, the salt pack is the best dressing in times of pressure. But it must be carefully and exactly applied; a little extra time devoted to the proper application of the dressing is repaid by the absence of any further need for disturbance of the wound during the short time that the patient remains in the casualty clearing station. Wounds involving the main vessels of a limb, and fracture with much comminution, are not suitable for the typical salt pack.

I am fully conscious of the inadequacy of this paper; the subject involves so much tedious detail that the principle of wide excision has been ruthlessly applied in its preparation; but I have tried to lay stress on what I believe to be the most important part of the treatment of a wound—its early operative cleansing—without infringement on the subjects of those who are now to deal with regional surgery.

DISCUSSION ON THE PAPERS OF DRS. DAVIS, BEVAN, HARTWELL AND BUTLER, JONES, GIBSON AND ELSER

Major George Dehelly, Le Havre:

I will discuss a part of these statements. This afternoon in reading my paper on "Closure of Wounds," I will include the discussion about the time of operation, about the best operation to do and the advisability of closing wounds with or without bacteriological examination.

But about the organization of the central system, I can say that the actual organization is difficult with trench warfare. The casualty stations provide the most valuable service. The patient must be in the hands of good surgeons, and it is necessary to organize close to the Front the best surgical service possible. But this organization is made too fixed, and with a new warfare it is sometimes impossible to move patient or material, and probably, I think, it will be necessary to reorganize a new service. We must certainly have very good organization brought close to the Front for our patients, but we must also have the opportunity of moving such organization at short notice because we have found in the actual work that many of our wounded have been taken prisoners, due to the difficulties now encountered in transportation. We must keep close to the Front Line the slightly wounded, but those suffering with wounds of the soft tissues or fractures should be sent at least fifty kilometers to the rear in order that necessary operations may be promptly done. Keeping close to the Front all our patients, it is a necessity of surgery to repair our patients quickly, since the military conditions make it impossible to transport them to great distances. The organization on the French Front during the past three years has progressed so far that there may be difficulty in a complete reorganization, but our experience shows that at each clearing station we must have good surgeons; but it is impossible, of course, to have specialists; it is very difficult to have an orthopedist in each evacuation hospital; it is impossible to have a man trained for brain surgery, but of these specialties all good general surgeons must learn the general principles; it is not very difficult. We have many assistants who are general surgeons who can quickly adapt themselves to these specialties.

The work done by Cushing and Demartelle is good; it does not differ very much from the work done by the general surgeon, but it is very good to have the accurate opinion of a man who has specialized in this branch of surgery, and it also provides the means of conveying this special information to the general surgeons.

It is necessary to teach older surgeons about every kind of surgery, because, as I have said, it is impossible to have a specialist in every center.

Those specialists who are close to the Front can teach all the other surgeons, and it is not very difficult to teach a general surgeon orthopedic principles or to teach him the general principles with regard to fractures. The treatment by the general surgeon must be bent toward the prevention of infection; this is the first principle of war surgery.

First, remove infection from the wound, then it is possible to send the patient to a specialist, if it is necessary; but it is imperative that the surgeon who first sees the case understands the necessity of preserving the essential parts of the joints. He must know the classical resection of the joints, which is oftentimes better than an atypical resection. At the beginning of the war, joints were not properly taken care of. In ankylosis of joints we have learned that the expectant treatment is many times more valuable than a large resection. The general work now is to make as good a cleansing at the beginning of the treatment as possible, then to close the wound, if possible, and then, I think, there is no other means to treat the infection than by applying an antiseptic method. It is not absolutely correct to say now by good surgery and by control of infection it is not necessary to employ antiseptics. I could show, if necessary, that not one wound is suppurating in the hospital, but that many wounds are suppurating.

Last November I saw many British base hospitals, and I was in one during the last battle of Flanders, with the American Unit from Cleveland and St. Louis, and I helped Dr. Fred. Murphy for several days. All the wounded coming from Flanders were suppurating, and it was necessary to treat all these patients by antiseptic methods. When we find something better, then it will be time for us to say that we have no more use for antiseptics; but at present we require, first, good surgical treatment, and if this is not sufficient, the employment of a recognized antiseptic method, since we have no other means at our disposal for controlling infection in wounds.

Dr. Samuel C. Plummer, Chicago:

I want to speak of one thing pointed out by Dr. Hartwell, that is how, on a scientific basis, they found that it was poor policy to begin the Dakin treatment at an early stage, but that when the secretion became purulent the solution was efficient. In order to get at the practical clinical basis of treating these chest cases I found my experience at Camp Custer valuable.

At first these cases were operated on by excision of the rib at an

early stage (and this fluid collected in the chest with remarkable rapidity), and the Streptococcus hemolyticus was an almost constant factor; in such cases the early operation of resection of the rib was followed by shock in many instances and about one in every three cases succumbed. It was therefore decided to adopt a plan as follows: First, to aspirate when the amount of fluid became sufficient to embarrass the breathing; when the fluid became purulent a small puncture was made, a tube put in, which could be intermittently drained. The collapse of the lung was thus avoided. When the fluid became entirely purulent the rib resection was done. We were fortunate in having at that hospital a man thoroughly trained in the technic of the Carrel-Dakin treatment, and at first I must confess to doubting the efficacy of this treatment, but after observing his results I became convinced of its value.

Sometimes after using it for only three times no pus whatsoever would drain from the wound. After twenty-four hours the fluid would be clear and the bacteriological count low.

Dr. Edward W. Archibald, Montreal:

All these papers have been interesting, and I may add that to us Canadians who have had a taste of the work abroad, it is encouraging, and, indeed, inspiring, to see the way in which you in the States are taking hold of these big problems and your ingenuity and ability in perfecting methods.

Dr. Bevan's paper in particular invites discussion. I think we must agree with him, in the main, about organization. It is true that the general surgeon must be the controlling factor. Yet the general surgeon himself must approach the subject with the proper modesty. He, too, in this war is inexperienced as well as the brain surgeon, the dentist and other specialists. We had to learn an awful lot, and we have not yet stopped learning. The general surgeon should take the attitude, when he goes across, that, while he maintains general control, he must encourage specialism among his juniors. I think the ideal man among the juniors should be a man from thirty to forty, breaking into general surgery, who has served as intern and later as resident surgeon, and who still retains his maximum strength and enthusiasm. This man should be encouraged to take up special branches, such as cerebral surgery, the treatment of joints, the treatment of chest and abdominal wounds, according to the hospital in which he is situated. There is no doubt that the general surgeon has a great deal to learn of war surgery, and that he cannot learn it all. Our results in chest surgery for infected hemothorax, in cranial

wounds, and joint wounds, have improved immensely, but no one man can keep up to date in all of it.

Dr. Jones's paper on the role of the evacuation hospital in the care of the wounded applies particularly to the year 1916. I remember very well in December, 1915, talking to the commanding officer of a casualty clearing station and saying to him: "The proper thing would be to put your general hospital where the casualty clearing hospital is: that is, within a few miles of the Front, because your casualty staff never will be big enough." He said: "You forget the army munitions and other supplies come first; the transport system would not bear the extra strain at present; we cannot do it yet." Now we have changed that and we have sufficient appropriation of transport. At that time it was trench warfare, now it is open warfare. We must devise means by which not only may the wounded be properly cared for and every wound properly cleansed, but also means by which the Front Line hospitals can be made very mobile. The French with their "autochirurgie" have tackled that problem; you are sending mobile operating ambulance units; you will get splendid results from the combination of perfected means of surgical work and great mobility in Front Line hospitals.

Dr. Alexis V. Moschcowitz, New York City:

In discussing the paper of Dr. Hartwell I shall confine my remarks only to one or two points. My experience with the Carrel-Dakin treatment is not devoid of interest and places me in a somewhat peculiar dilemma. When an outline of this treatment appeared in medical journals the method appeared to me to be so inviting and so easy that I introduced it into my service at Mount Sinai Hospital. After giving it a faithful trial for three months I discarded it as being valueless. Much to my discredit I even went so far as to condemn it publicly. Subsequently, when Dr. Carrel opened the War Demonstration Hospital in New York City he extended the courtesies of the same to me and I availed myself of the opportunity to visit it regularly for several weeks. I soon learned wherein I made mistakes. I promptly reintroduced the method at Mount Sinai Hospital and have become an enthusiastic advocate of the method in all infections.

As regards the question of the treatment of empyemata I have made several very interesting observations during my connection with the Empyema Commission. First of all, sad experience has taught me the inadvisability of immediate operations. If a case of empyema is operated immediately upon the recognition of the presence of an infected exudate the outlook for a favorable termination is very

dubious. First, because the patient is too sick to be operated, having to contend not only with the empyema, but also with the underlying pneumonia; and second, because at this stage of the empyema the lung is still free and not adherent anywhere. It follows therefore that when the thorax is opened to permit the escape of the seropurulent fluid the lung collapses and a dangerous hyperacute pneumothorax is added to the numerous other burdens with which the afflicted individual has to contend. We have therefore decided to operate cases only when frank pus has been found. Since adopting this method we have noticed a marked improvement in our mortality statistics. Prior to the operation we watch the fluid carefully, and when its quantity is sufficient to cause an embarrassment of the respiration or circulation it is withdrawn with a Potain aspirator.

The postoperative treatment is carried out according to principles laid down by Carrel. We have succeeded in sterilizing most of the cases very satisfactorily, but prefer to leave the ultimate closure to natural forces.

Dr. G. G. Davis, Philadelphia:

With regard to specialization in war surgery, I would say that the men who are taking up orthopedics almost without exception are experienced general surgeons of undoubted ability whose interest in this specialty should not be restricted. I would call attention also to the gross surgery of the joints in the hands of the general surgeon, laying stress upon the fact that he must assume the responsibility in these cases and not be satisfied with one corrective operation.

Dr. John A. Hartwell, New York City:

In reference to Dr. Dehelly's statement, we find at the present time the closure of wounds with 80 per cent. primary union does not seem an actual fact in the base hospitals. Certainly, in the civil hospital we have not secured such a high percentage of primary union in badly traumatized wounds, and when we do not get primary union there is nothing so effective in bringing about the quickness with which we can do a secondary suture as Dakin's solution following the technic of Carrel and carefully watching the bacteriological changes.

My second point is in reference to the treatment of empyema. It was brought out by Dr. Moschcowitz that in some of the hospitals they have not only been using Dakin's solution to wash out the cavity, but have actually been plugging the opening with resection of the rib through which the fluid is evacuated and then the Dakin solution is run in under pressure. That invariably will break up adhesions and

drain unaltered Dakin solution into the normal pleural cavity, which will then be likely to damage the cavity. This must be controlled by an easy egress of the fluid.

The third point is that in our close association with the medical library, Benedict has brought about a new method of making Dakin's solution by using chlorin gas run through sodium carbonate. He can thus make 30 liters in twenty to forty minutes, and it never varies the slightest in the reaction between 0.46 and 0.48 of 1 per cent. This certainly is a very great advance on the former methods of producing it, and has proved absolutely satisfactory in all our work.

Dr. Charles L. Gibson, New York City:

One word regarding what is being done on the other side from the standpoint of civil practice at home. I want to insist that we must be prepared at any moment to throw overboard all preconceived opinions. There has never been such a war before, and all military operations have had to be revised. There is an element of sepsis, of infection, in war conditions of which you can get no parallel at all in civil practice. First the question of compound fractures as a result of warfare. You do not have that 100 per cent. element of infection in civil life as you do in military practice, and, moreover, a large proportion of civil fractures are by indirect violence. There is little or no damage to the tissues, whereas in military surgery, fractures result from direct trauma, with enormous damage to the soft parts.

LOCALIZATION OF FOREIGN BODIES BY MEANS OF THE ROENTGEN RAYS

By MAJOR WILLIS F. MANGES, M.R.C.
PHILADELPHIA

Localization of Foreign Bodies. So much has been written on this subject that you must wonder what more one can say that will be of interest. It is perhaps to be regretted that so much has been written, for there have been so many rediscoveries that now there is considerable confusion as to the real inventor of a method. The March number of the *American Journal of Roentgenology* contains an article by Lieutenant-Colonel J. T. Case, M.R.C., Director of Roentgenology, A.E.F., on "The History of the Localization of Foreign Bodies." One need but glance at this to realize that it is difficult to place credit always where credit is due or even hope to read all of the works to which he refers and at the same time help win the war. Certainly, this is no place to read history to any extent.

We have assumed that it might be acceptable if we should tell you what provisions have been made in this connection for the American roentgenologist and then try to show you the duty and responsibility of the roentgenologist as well as the surgeon. There can be no questioning of the statement that each has an entirely separate responsibility and that failure may follow from inaccuracy at operation as well as from inaccuracy in measurement.

In military affairs, as you know, standardization is an absolute necessity. There was a lamentable lack of it in the roentgen-ray apparatus available in this country at the time we entered the war. The Surgeon-General of the Army realized this and appointed Major Arthur C. Christie, M.R.C., of Washington

(now Lieutenant-Colonel, National Army), and Dr. George C. Johnston, of Pittsburgh (now Major, M.R.C.), to bring about the standardization of roentgen-ray apparatus to meet the requirements of the military organization.

The work of this committee is briefly described in an article by Major Arthur C. Christie, M.R.C., *American Journal on Roentgenology*, January, 1918.

The committee has accomplished a difficult task in a most commendable manner and we now have a large amount of apparatus available for use both at home and abroad.

While the committee on standardization of apparatus was at work the Committee on Preparedness, appointed by Dr. L. G. Cole, then president of the American Roentgen Ray Society (now Major, M.R.C.), set itself the task of organizing schools for instruction in military roentgenology, of collecting material for a manual, and of recruiting as many roentgenologists of the country as possible.

This committee was aided by a larger advisory committee. With the approval of the Surgeon-General of the Army those men selected as instructors were assembled in New York for two weeks in June, 1917, for the purpose of outlining the course of instruction to be given. At this conference Dr. David R. Bowen, Philadelphia, Pa., presented a paper describing the various principles involved in the localization of foreign bodies and illustrated quite a number of the methods in use in the hospitals of our Allies.

The conference then selected five of these methods as the ones to be taught in the various schools.

Portions of Dr. Bowen's article became the material for the chapter on Localization of Foreign Bodies in the *Roentgen-ray Manual*, United States Army. One additional method has been added in the meantime.

As the work on standardization of apparatus developed it was found desirable to modify the localization devices so as to be more adaptable to the standard American apparatus. The results again are most excellent and largely due to the New York School of Military Roentgenology, and especially to Major J. S. Shearer, Major Eugene Caldwell and Captain E. S. Blaine.

A new edition of the *Roentgen-ray Manual* is about to be published, and will include all these later developments.

To give a complete description of these various methods would occupy more than the time allotted, but we will present them briefly in the order given by Major Shearer, who was so good as to send me the advance sheets, as well as illustrations, of his article on this subject as presented in the *American Journal of Roentgenology* for May.

Method A, or more generally known as the Strohl method, depends upon the construction of similar triangles, the relation between the base and altitude of which is known.

Method B, the so-called parallax method, described independently and modified by many workers, depends upon the fact that if opaque objects are at the same level their shadows will move equally when the tube is shifted at right angles to a line joining the two bodies.

Method C, the single tube shift method, or the triangulation method, has been in use in one form or another for many years. The distance from the focus point of the tube to the screen is known, the distance of the tube shift and also of the shadow shift are measurable. It is possible then by means of an instrument to visualize these measurements and show the relation of the foreign body to the screen or skin surface. It is a fairly rapid and accurate method, but has no special advantages over *Method A* or *B*.

Method D, the so-called profondometer method, has been thoroughly described by Major J. M. Flint.[1] This method involves the use of a cross-section anatomy and gives the information that the foreign body is in relation to a certain anatomical structure, so that the surgeon may operate from the most desirable point on the surface and proceed without definite regard to a perpendicular.

This procedure is not practicable except in selected cases, at times of comparative inactivity, and where there is only one foreign body.

[1] Annals of Surgery, August, 1915, and Military Surgeon, March, 1917.

Method E. The compass method of Hirtz. This is an instrument which permits of adjustment either by means of tracings taken from radiographs or more rapidly by means of the fluoroscope, and when in adjustment may be sterilized and taken to the operating table and used as a guide to the foreign body. The depth of the foreign body is determined by *Method A*, *B* or *C*, when the instrument is adjusted by means of the fluoroscope.

In 1906, at the Jefferson Hospital, Philadelphia, Pa., the writer adapted an American-made localizer, so that it could be sterilized and used at the operating table. We were especially pleased with this method in the removal of bullets from the brain, chest and spinal canal.[1]

Method F. Intermittent control. By this is meant that a roentgen-ray tube is under the surgical operating table and the roentgenologist from time to time determines the nearness of the surgeon's instrument to the foreign body. This method is reserved for cases in which the surgeon does not readily find the object localized by one of the other methods and for multiple small bodies. This will probably be replaced to some extent by the stereofluoroscope, by means of which both the surgeon and the roentgenologist can see the shadows of the foreign body and the instrument in perspective and the surgeon can approach the body with his instrument much as he would reach out into space and grasp a definite object.

This apparatus has been developed by America's premier roentgenologist, Major Eugene W. Caldwell, M.R.C. Tests being made of the first unit are very encouraging.

Method G. The trocar and cannula method of Sutton. In this method the trocar and cannula are brought in contact with the foreign body under fluoroscopic control. The trocar is removed and a wire hook inserted through the cannula to engage in the tissues immediately adjacent to the foreign body. The cannula is then removed and the wire remains to serve as a guide for the surgeon.

These methods, excepting the stereofluoroscope, have stood

[1] Proceedings American Roentgen Ray Society, 1908.

the test in the hands of the roentgenologists and surgeons of our Allies, as well as the American roentgenologists already in the field, and have been adopted largely on the advice of Lieutenant-Colonel James T. Case, M.R.C., Director of Roentgenology, A.E.F., who has visited many hospitals in Europe and made a special study of this phase of the work.

They are being taught fully, and in such a way that the roentgenologist will be able to give an intelligent interpretation as to his findings. Each method has its advantages, but not any one would be sufficient.

It is hoped that the surgeon will be content to accept the assortment and not expect the roentgenologist to be proficient in any other, at least not until after he has had a great deal of practical experience with these.

Duties of the Roentgenologist. The duty of the roentgenologist, in so far as localization of foreign bodies applies, is primarily that of an assistant to the surgeon. We feel that in the great majority of instances he will prove to be a very valuable assistant and in many the most valuable of the entire staff. Upon his skill will depend largely the efficiency of the organization he serves.

Let us consider his responsibilities: The roentgenologist is the first to know of the presence of the foreign bodies, the number, size and location. He determines very promptly the approximate location, selects the point on the surface through which he believes the surgeon would elect to operate and then makes the necessary measurements. During times of activity he must do this with great rapidity, and the point of selection must be the proper one in the vast majority of instances or he fails to render the assistance needed by the surgeon. He is called upon constantly to apply his knowledge of anatomy and to exercise surgical judgment of the highest type. The localization must be accurate, the method used must permit of great speed and minimize the manipulation of wounded parts, for jagged shell fragments and sharp bone fragments may under manipulation cause great additional damage.

There is but small chance that the depth measurement may be

inaccurate. Only carelessness or shifting of some usually fixed portion of the apparatus could be accountable for such error. The danger lies in having the patient in one position on the radiographic table and in a different position on the operating table, for this changes the vertical or horizontal that prevailed at the time of localization.

We believe this could be minimized if the suegeon and the roentgenologist could agree upon certain standard positions to be used in all but exceptional cases. Again, it is possible to indicate on the skin the other end of the perpendicular or horizontal and thus aid the surgeon to get the patient in the same position as at the time of localization, or at least he will have two points between which the foreign body is to be found.

The roentgenologist works for hours at a time in a room which must permit of total darkness and at no time may there be more than a fairly dim red or blue light. Such rooms are not usually well ventilated, so that the operator is subjected to fatiguing conditions, and yet he must keep alert and active.

During less active times the surgeon and roentgenologist have opportunity to confer as to the desirable point of localization and apply one of the methods that furnish additional guides at the time of operation. *Methods D, E* and *F* may then be added to one of the former. This affords the surgeon much more latitude as to his incision. In many cases, in fact, such procedure is essential. The responsibilities of the roentgenologist are then lessened in so far as surgical judgment is concerned, but these localization methods require more skill, time and care.

The Duties and Responsibilities of the Surgeon. Primarily, of course, the duty of the surgeon is to repair wounded men expeditiously and return them to duty or to evacuate them with the least possible delay. To this end his work must be done rapidly and well, and, in times of great activity, his skill and endurance may be taxed heavily. With relation to foreign bodies it follows that he must remove them in the vast majority of instances or his work will have been in vain, his duty unaccomplished.

Here then are two separate duties and two distinct phases of responsibility. Ultimate success will follow promptly in a high percentage of instances if each in his turn has done his part well. Failure or unwarranted delay, which is not greatly better, will ensue if the roentgenologist does not give accurate directions and measurements, as well as if the surgeon fails to properly follow accutate directions and measurements.

Since it is not practicable for the surgeon to do his own roentgen-ray work, or possible for the roentgenologist to attend every surgical operation, it becomes desirable to correlate the responsibilities in other ways.

There must be hearty coöperation between the two. Every American surgeon who operates for the removal of foreign bodies should understand minutely the above methods of localization and as much of the practical side of roentgenology as is necessary in order that he may fully appreciate the limits of the processes involved. For instance, splinters of wood or fragments of clothing, leather and such other materials cannot, under ordinary circumstances, be detected by means of the roentgen rays. Therefore, if such foreign bodies are not removed at the primary operation, it is certainly not the fault of the roentgenologist, and may easily not be the fault of the surgeon. There have been reported instances of the localization of fragments of clothing in the depths of suppurating sinuses after the injection of a bismuth salt or barium sulphate in emulsion.

Collections of air in the tissues, if present in appreciable quantity, may easily be detected by means of the roentgen rays, because of the relative lack of opacity. Recourse to this study should be had early in suspected cases.

This sort of information we hope the roentgenologist will be able to give. On the other hand we believe much would be accomplished if the surgeon would lay down as nearly as possible definite rules for placing the patient so that the position would be the same on both the radiographic and operating tables. For instance, how shall the arm, forearm and hand be placed if there is a foreign body in the axillary region? How shall the thigh,

leg and foot be placed when the foreign bodies are in some portion of this extremity? Manifestly, large open wounds, especially wounds of exit, may interfere with localization in a standard position, but this does not invalidate the importance of the idea of standard positions.

We believe that the most important points for the surgeon to keep in mind at all times are: (1) direction, and (2) depth measurement.

By direction, we mean the line from the skin mark to the foreign body determined at the time of localization, and it may be a perpendicular or horizontal. If the surgeon encounters muscle borders, large vessels or nerves in following this line he must not forget that muscles, vessels and nerves were not retracted at the time of the localization, so that, if by necessity he must turn temporarily away from the line, he should retract and manipulate as little as possible and immediately return to it.

As to depth, assuming that the measurement has been made accurately, it must be insisted that the surgeon go to that depth before expecting to find the foreign body, especially if the object be a comparatively small one. The large shell fragments are easily found, as a rule, but the smaller ones cannot be felt easily unless the direction and depth have been followed with accuracy.

In short, the surgeon should revert to his early educational efforts and once more become enthusiastic about geometry, for perpendiculars, parallels, horizontals, angles and triangles are most important matters in this connection.

And then there is that indescribable something which, for want of a better term, we will call "localization sense." One surgeon develops it quickly and another has more difficulty, but it is well to keep in mind that the surest way to get it is to be most intimately acquainted with the methods of localization that are in actual use and then develop the sense of direction, distance and delicacy of touch to the utmost.

The important thought in this paper is that there should be wholesome and constant coöperation between the surgeon and roentgenologist.

DISCUSSION

Dr. Charles L. Gibson, New York City:

I wish to congratulate Major Manges on his wise attitude in accepting well-known and tried methods of the French school. I speak particularly of the French school because I am more familiar with their methods. The French have published a most excellent book on the localization and extraction of projectiles, and this book should be in the library of everyone interested in military surgery.

In this book the author speaks not only of *x*-rays, but what is also important, other methods are described. I was very much impressed when visiting Depage in 1916 to find that in locating foreign bodies one must be prepared to use more than one method, we must have all resources. In addition to the method Major Manges described, the French make use, sometimes as a main method, sometimes as an adjuvant, of the various forms of vibration. For instance, the electromagnet is brought into the wound and the surgeon, placing his hand in the wound, feels the vibration. There is another form of vibration based on the principle of the telephone probe; that is, an auditory recognition and the advantage of not requiring actual contact. This little magnet is carried under the index finger into the wound. If a needle or foreign body is present, a very distinct buzz will be heard in the ear. In the choice of any method, speed is of importance; especially in the evacuation hospitals.

AN APPLICATION TO EMPYEMA OF THE PRINCIPLES UNDERLYING THE USE OF ANTISEPTICS

By EDWARD K. DUNHAM, Major, M. C.
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On this occasion it has seemed to me best to give a clinical trend to my remarks. The opportunity to do this has come through experiences acquired in association with other officers of the Medical Reserve Corps in the antiseptic treatment of cases of empyema in a Base Hospital in one of the Cantonments of the National Army. In this way I hope to avoid a too strictly academic mode of presenting the subject.

Stated in briefest terms, laboratory experiments have shown that the three primal factors in the progress of disinfection are: Contact, mass and time, the first being made absolute, the two later correlated. In these respects the process of disinfection is closely analogous to a simple chemical reaction, the antiseptic and bacterial cytoplasm constituting the reacting substances.

In clinical practice much more than mere deductions from the foregoing almost self-evident generalizations must be taken into consideration. Individual antiseptic substances differ greatly in speed of action, toxicity and the range of reactions they may enter into other than those upon which their germicidal potency rests. All these properties may seriously affect their surgical usefulness as well as determine the modes in which they can most efficiently be employed.

The cases of empyema to which I have just referred resulted from infection with the hemolytic streptococcus and were most frequently secondary to measles and a somewhat unusual type of

bronchopneumonia. Such empyemata differ considerably from those occasioned by the pneumococcus in severity and persistence and present a rather difficult problem in disinfection.

The pleural exudate is abundant. At first serous or serofibrinous, it rapidly becomes purulent. There is a fibrinous deposit of considerable thickness upon the pleural surfaces, which persists after suppuration has become established and, at autopsy, presents a shaggy fibrinopurulent coat not readily detached from the underlying structures.

The number of microörganisms in the exudate is very great. Sometimes as many as 10,000,000 have been observed in a single drop and from two to four millions are frequently present. Very rarely is there any evidence of local immunity. The leukocytes in the exudate are usually necrotic and only occasionally are there indications of a moderately effective phagocytosis.

The cavity occupied by this exudate may have a capacity of one or two liters and a configuration of considerable irregularity due to the coalescence of previously separate pockets or the presence of pre-existent adhesions. Access to this cavity is usually secured by the resection of a single rib.

It is obvious that the conditions presented by these cavities oppose great difficulties to be overcome in obtaining satisfactory disinfection. There is no opportunity to effect a mechanical cleansing such as would be the first step in open wounds accessible to direct surgical intervention. Even to secure perfect drainage is a problem requiring careful individual attention in each case, and is frequently a matter of uncertainty, owing to the difficulties of exploration.

To overcome with antiseptics a massive infection under the circumstances just outlined, it is important that the agent used should act quickly, since the abundant discharge tends to both dilute and remove any application. It should neither occasion precipitates with constituents of the exudate nor have a hardening effect upon fibrin. And it should not be toxic.

The members of the chlorine group of antiseptics offer better promise of completely meeting the requirements than any other

substances with which we are familiar. But, for their effective application certain definite conditions must be met. Active chlorine, to which these substances owe their antiseptic value, is not a specific germicide. It reacts with many substances invariably present in exudates and these reactions materially reduce or may even entirely abolish the germicidal action; the chlorine passing into more stable and inert combinations. Contact with the exudate may so reduce the mass of antiseptic that the time during which it can act is insufficient for adequate germicidal effects. This is what actually occurs in practice when treatment is begun in these cases. The very reactivity upon which the value of these compounds as germicides depends curtails the time during which they exert this action.

There are three active chlorine compounds available for use in surgical practice: neutral sodium hypochlorite or Dakin's solution, chloramine-T and dichloramine-T in an oily solution prepared with chlorcosane as a solvent. The permissible concentration in which these can be used without undue irritation differs. Half of 1 per cent. is the limit for the hypochlorite, 2 per cent. or thereabouts for chloramine-T, and from 5 per cent. to 8 per cent. in chlorcosane for the dichloramine-T. The hypochlorite is, therefore, available in least concentration. It is also the most rapidly reactive of the three and, in consequence, most transient in its action. There is, however, one consideration which makes it of greater value in the treatment of these empyemata than either of the chloramines. This is its markedly favorable influence upon the dissolution of fibrin. This action also entails the loss of active chlorine and we return once more to the necessity of maintaining the mass of applied antiseptic in order to attain satisfactory disinfection.

Since, in the use of sodium hypochlorite, the mass of antiseptic cannot be continuously increased by raiding the concentration of the solution employed, this must be accomplished by fresh additions in quantity exceeding at any given time the rate at which the substances rendering the chlorine inert accumulate in the exudate. During the first day or two this may require an

hourly instillation of as much as 100 c.c. of Dakin's solution, distributed as completely as possible to all parts of the cavity by means of Carrel tubes. When such quantities are used, it is important to provide a drainage tube for the reflux. The progress of disinfection is greatly facilitated by a thorough irrigation with the solution at intervals not exceeding twenty-four hours, for this removes any large accumulation of reactive substances that may exist in the free fluid.

The progress of disinfection can be followed very satisfactorily by inspection of the dressings and the return during irrigation or by direct bacteriological examination with smears or plate cultures. The first effect is the abolition of odor in those cases in which there was a foul discharge. Until this is accomplished there is very little apparent effect upon the purulent character or the amount of the exudate. Neither is the bacterial content materially affected. But after a day or two the amount of pus diminishes and there is less secretion from the wound.

Subsequently the character of the discharge undergoes a striking change. The pus either entirely disappears or is present in very small amount and the secretion becomes viscid, mucoid and transparent, resembling uncooked white of egg. A day or two later this also disappears and there is then little if any discharge. At this stage it is very difficult to cultivate microorganisms from the contents of the cavity, for it is substantially sterile. In no case could hemolytic streptococci be detected. If the cavity is now irrigated with Dakin's solution and the patient coughs or blows against resistance, there is good evidence of lung expansion even in protracted cases and repeated coughing causes the appearance of traces of blood in the outflowing fluid.

Considerable interest attaches to the appearance of the mucoid material, the increased freedom with which the lung expands and the slight hemorrhage. The viscid substance responds faintly, but distinctly, to tests for active chlorine and appears to be a chlorinated product of fibrin. Its presence can probably be attributed to the action of the hypochlorite upon the fibrinous deposit on the pleural surfaces, an action which comes prominently into play only when there is little pus to consume more rapidly the

available supply of active chlorine. The trivial hemorrhage induced by moderate disturbances is in harmony with this supposition. Observation at autopsy of a bilocular cavity in which only one division was accessible to adequate treatment with Dakin's solution also offers confirmatory evidence. The pleural surface of the treated cavity was covered with thin granulations, while the untreated portions were heavily coated with a shaggy fibrinopurulent deposit.

Pleural surfaces, free of fibrinous deposit but covered with fine sterile granulations, are in condition to unite with the formation of desirable adhesions if they can be brought and kept in contact for a moderate length of time. A limited experience makes it probable that the lung under these conditions spontaneously tends to expand, but that this can be hastened by the use of a flutter valve, bottle-blowing, deep breathing and other procedures.

Infection of the pleura in the cases under consideration is probably invariably secondary to a pulmonary infection and in at least many cases an intermediate lesion is a subpleural abscess. This may be minute or of considerable size. In the latter event, perforation into the pleural cavity may lead to a communication with a bronchus. This precludes irrigation of the pleural cavity with Dakin's solution, but cautious intermittent instillation frequently occasions no inconvenience.

Attention need, perhaps, hardly be called to the fact that the foregoing treatment with Dakin's solution must be unremittingly maintained to attain the most satisfactory results. If the supply of active chlorine be too greatly interrupted before adequate disinfection is accomplished, there is certain to be a retrogression of the process.

It is possible to substitute a 5 per cent. solution of dichloramine-T in chlorcosane for Dakin's solution, making the application once or twice in twenty-four hours after irrigation with sterile saline or a weak aqueous solution of chloramine-T. The oily solution of dichloramine-T is not irritating to the walls of the cavity, though, like Dakin's solution, it not infrequently affects the unprotected skin where there are no secretions appropriating the active chlorine. Disinfection appears to be somewhat less rapid

and the removal of fibrin a degree less satisfactory than when the hypochlorite is used. But that the fibrin does come away is evident, for thin sheets of considerable area may be easily detected in the discharge and are frequently so abundant as to clog the drainage tubes. Where facilities for the proper application of Dakin's solution are not at hand, it will be much more satisfactory to employ dichloramine-T as entailing less apparatus and unremitting care. The mass of antiseptic introduced at a time may be many times greater without injury, since it comes into play gradually as it passes from the oil only to maintain a moderate concentration of active chlorine in the aqueous medium.

Under favorable conditions it is reasonable to expect sterilization of an uncomplicated empyemic cavity with Dakin's solution in from five to ten days. To accomplish this the cavity must be accessible to the antiseptic throughout its whole extent and the mass of antiseptic introduced must be sufficient to exert a reasonably persistent action over a period required for disinfection in spite of concomitant reactions. Many of the latter are desirable. Among such are the deodorizing and detoxicating action of the chlorine compounds as well as the effect of hypochlorite and to somewhat less extent of dichloramine-T on fibrin and necrotic tissue.

Although it appears essential for the rapid relief of the local condition in these empyemata, the antiseptic treatment of the pleural cavity does not meet the full needs of these patients. Their nutritive requirements are very great. This is shown by the rapid loss of weight and strength on ordinary diets. A very limited study has demonstrated a loss of nitrogen which may amount to 23 grams a day. How can one look for the development of a general immunity on nitrogen starvation?

The nitrogen of the body can be conserved by raising the calorific value of the food taken. To bring the patients into nitrogenous equilibrium from 3000 to 3500 calories are required. These may be supplied in the form of readily assimilable carbohydrates as well as fats and proteins. The addition of milk sugar to egg-nog, cocoa or other beverage is a convenient way to augment the calorific intake.

THE PHYSICAL FACTORS INFLUENCING INFECTION

By WALTON MARTIN, M.D.
NEW YORK, N. Y.

I HAVE used the word physical with the idea of discussing the relative importance of certain mechanical features which influence the initial lodgment and the persistence of infection. I have not had in mind the consideration of the effects of physical forces such as light, heat or electricity on the growth of microorganisms within the tissues.

During the war the whole subject of infection has been studied under very special conditions. All the injuries by artillery projectiles and rifle and machine-gun bullets at close range are heavily infected, and, as we all know, this has been the usual type of injury in the warfare of the past three years.

If left to themselves or treated conservatively they regularly develop infection, often of a type and severity rarely seen in civil practice. The evolution of these lesions has been studied and methods of treatment suggested not only by surgeons whose work in civil life, in great industrial centers, has accustomed them to the treatment of infected wounds, but also by those trained in the technic of experimental laboratories, by pathologists and chemists. An intensive study has been made by these different groups and the whole subject considered from many fresh and stimulating points of view. But no essentially new surgical problems have been presented, attention has simply been turned from measures directed toward the prevention of the introduction of microörganisms after the wound is inflicted to means of combating infection already implanted. At the outbreak of the war the ruling idea was the avoidance of secondary infection.

It is common knowledge that pyogenic microbes are frequently introduced into the body without producing any pathological effect. They enter the tissues and are destroyed there by the activity of the body cells. We know that many accidental wounds are contaminated by pathogenic microörganisms and yet heal without evidence of infection. Operative wounds are frequently soiled by bacteria in performing gastro-enterostomy, intestinal resection or in the removal of an infected appendix, and yet heal by primary union. Infection is uncommon in gunshot injuries seen in civil practice made by bullets of low initial velocity. Eighty-five per cent. of the injuries from the pointed modern rifle bullets in the Japanese-Russian War healed without reaction according to von Oettingen.[1] In all these injuries bacteria are introduced into the wound but the relation between tissue vitality and microörganisms is such that infection does not occur. The wounds are contaminated but not infected—that is, there is no clinical evidence of the group of reactional phenomena, either local or general, which we are accustomed to consider as furnishing evidence of infection. It has been shown experimentally that a few bacteria can be introduced without producing any effect, that larger doses cause local infection, whereas death regularly follows injection of very large numbers. It is well known that bacteria have not a fixed virulence, and that their toxic action can be exalted or attenuated by a number of causes; but aside from the dosage and virulence of the microbes, and the susceptibility of the individual inoculated, there are certain factors purely mechanical which play a most important part in determining whether or not the microörganisms gain foothold in the tissue and multiply there and control their progress when they have become established in the tissue. That is, the gravity of infection is regulated by a number of mechanical conditions which are realized anatomically in certain wounds and not in others. These conditions are (1) pressure at the focus of infection, or point of initial lodgment; (2) foreign bodies; (3) devitalized and necrotic tissues; (4) dead spaces.

It is well known that an open wound is infected with difficulty.

whereas irregular wounds, punctures or lacerations are prone to infection. Obviously the welling up of blood and the outflow of blood and lymph must wash away foreign material. The ordinary pathogenic bacteria are non-motile. When they are brought into contact with the wound surface they can only find lodgment there, like any other foreign body, through some mechanical factor. So long as there is free flow from every part of the surface of the wound, they must be necessarily carried away. It is also evident that unfavorable conditions exist in the wounds open to light and air for the colonization of anaërobic organisms.

The question of the open wound and its relation to infection has been studied experimentally by Friedrich.[2] He amputated the tails of mice by a clean cut, then introduced the stumps into a virulent bouillon culture of anthrax and kept them there from five to thirty minutes. The animals all lived. In a second series he kept the wounded surfaces in the culture media for as long as three hours, then reamputated higher up. Three of these animals lived, in a fourth there was contamination during the reamputation and the animal died. All the control animals died after subcutaneous injection of the same culture in from thirty-four to forty hours. He concludes that even in susceptible animals highly virulent cultures of anthrax bacilli are unable to cause progressive infection if every possibility of creating local pressure and every mechanical adjuvant are removed.

The division of the different planes of tissue, skin, cellular tissue, aponeurosis and muscle, each with a different degree of elasticity and tensile strength, causes a shifting of planes one over the other, and this displacement of the layers is also brought about by any change from the position in which the wound is received. The deeper the wound, the nearer it approaches a puncture or perforation, the more marked is the action. It reaches the maximum in gunshot injuries where certain parts of the track of the missile may be completely shut off. Consequently the blood and lymph poured out from the severed tissues escape only partially externally; a portion spreads out internally along the

line of cleavage between the tissues. Foreign material introduced into the wound is then carried inward, not outward. The more irregular the wound surface, the greater the clefts and crevices, the less easily will bacteria be washed away by the lymph and blood. It must be remembered that even the surface of a clean-cut incised wound looks irregular and torn under the microscope; magnification of the blade of the sharpest knife shows a serrated edge and the severance of the body tissue by it inevitably causes irregularities large in relation to the size of the bacteria.

By friction, organisms are readily forced into the wound surface. The rapidity with which they are thus absorbed is well shown by the experiments of Schimmelbusch.[3] He found anthrax bacilli in the viscera ten minutes after he had vigorously rubbed them into an incised wound in the tail of a mouse, nor did amputation at this time prevent a fatal outcome. However, the pressure of blood issuing from divided vessels is usually sufficient to keep the pathogenic bacteria from entering the blood stream, and under ordinary conditions they start to grow, make toxins, cause tissue necrosis, determine a lymph flow and exert a positive chemotaxis. A wall of leukocytes surrounds the focus of infection. However complex the causes of these phenomena may be, whatever relation they bear to osmotic pressure or to chemotaxis, whether the cellular wall about the focus may be looked on as a semipermeable membrane, whatever the relation of the crystalloids and colloidal substances at the center of the focus, we certainly know there is created about a nidus of infection an accumulation of fluids under pressure, and whenever this pressure exists there are clinical evidences of inflammation and the relief of this tension by purely mechanical measures is regularly followed by subsidence of the manifestations of reaction to infection, and so delicate is this relation that the slightest increase in pressure is followed by a recrudescence of the symptoms. This is a surgical principle too well attested to discuss—it is the basis of all effort at wound drainage. It is the fundamental idea in the open treatment of wounds.

In wounds a mechanical barrier to infection is rapidly fur-

nished by a wall of leukocytes arranged along the wound surface; at first, to be sure, a delicate one and easily broken by trifling mechanical violence. Giani[4] showed this experimentally. He soaked filter paper in a virulent culture of anthrax, then laid the piece of paper gently on the surface of fresh wounds two, six, eight, ten and fourteen hours after they were inflicted. Even at two hours a third of the animals survived and in the ones in which infection occurred he was able to recognize, by slight signs of hemorrhage, a break in the protecting wall of leukocytes. At fourteen hours all recovered.

It has also been shown that even if bacteria become established and start to grow on an open wound surface, and there is no mechanical violence or pressure from without, their growth remains on the surface for a number of hours and can readily and certainly be removed by purely mechanical means. Friedrich[5] contaminated fresh wounds in mice with garden earth and street dust, then excised by a clean cut the surface tissue of the wound to the depth of 2 mm., using a sharp knife and taking care not to touch the fresh wound with instruments that had come in contact with the contaminated surface. Animals in which the excision was done within six hours all recovered. Those in which the excision was done after ten hours all died. Those done at seven hours showed marked signs of local infection, but finally recovered. After excision the wounds were left open. The prevailing organism was the bacillus of malignant edema. Controls died without exception in a short period of a type of gas gangrene.

Local pressure, then, has been proved experimentally, as well as practically, to be a physical factor of great importance both in the initial lodgment and in the persistence of pathogenic bacteria in the tissues.

Undoubtedly foreign bodies introduced into the tissues act unfavorably on the vitality of the surrounding cells. They act as both mechanical and chemical irritants. They seem to make it difficult for the bactericidal forces of the body to kill the microörganisms implanted with them. Gaffsky,[6] however, concludes an article on the relation of foreign bodies to infection

with the statement that they exert, as a rule, very little influence. He can hardly mean on the persistence of infection.

But the main significance of the foreign body is as a vehicle or conveyer of infection; it is a most effective means of carrying microörganisms into the tissues and lodging them there. Particles of earth, splinters of wood, fragments of glass, soiled and contaminated, are frequently embedded in the tissue. In gunshot injuries fibers and particles of soiled clothing, surface dirt, all manner of small objects are violently forced into the tissues, each with its modicum of infection. These bodies are more or less anchored in the tissues—the flow of lymph and blood is incapable of carrying them out.

How widespread is the fixation of infected foreign bodies in the tissues in gunshot injuries was pointed out by Müller[18] and Koller.[19] They showed by experiments in wounds by high-velocity modern rifle bullets that fibers of clothing were forced into the sound tissue surrounding the track of the missile, and it was possible to disinfect the track with caustics or the actual cautery.

In June, 1915, Policard and Phélip[7] made an interesting report on the histological and bacteriological findings about infected foreign bodies. They had studied and analyzed the biological processes of attack and defence about fragments of clothing introduced into the deeper tissues by shell fragments at periods varying from an hour and a half to three days after the wounds were inflicted, and the number examined had been sufficient to enable them to follow the evolution of the lesions. The blood from severed vessels is poured out about the foreign bodies at the time of the injury; it rapidly coagulates, obeying the well-known physiological law. This coagulation is often so rapid that the center of the wad of clothing is soaked with clear serum not impregnated with fibrin. Each fiber is glued in coagulum, and a sheath of coagulated blood is formed about each foreign body; in this enveloping mass the bacteria brought in on foreign-body fragments begin to germinate and the tissues about them here first show signs of reaction. This reaction ap-

pears from the fifth to the ninth hour approximately. From the ninth to the twelfth hour one begins to recognize the appearance of microörganisms having the characteristics of the Bacillus capsulatus aërogenes. From the twelfth hour three related phenomena appear and progress simultaneously. The bacilli multiply, at first about the foreign bodies; they radiate more and more from these as centers of infection. Second, there is an afflux of polynuclear leukocytes. Third, the leukocytes are transformed under the action of bacterial toxin into pus cells. These phenomena at first progress slowly, then with ever-increasing rapidity.

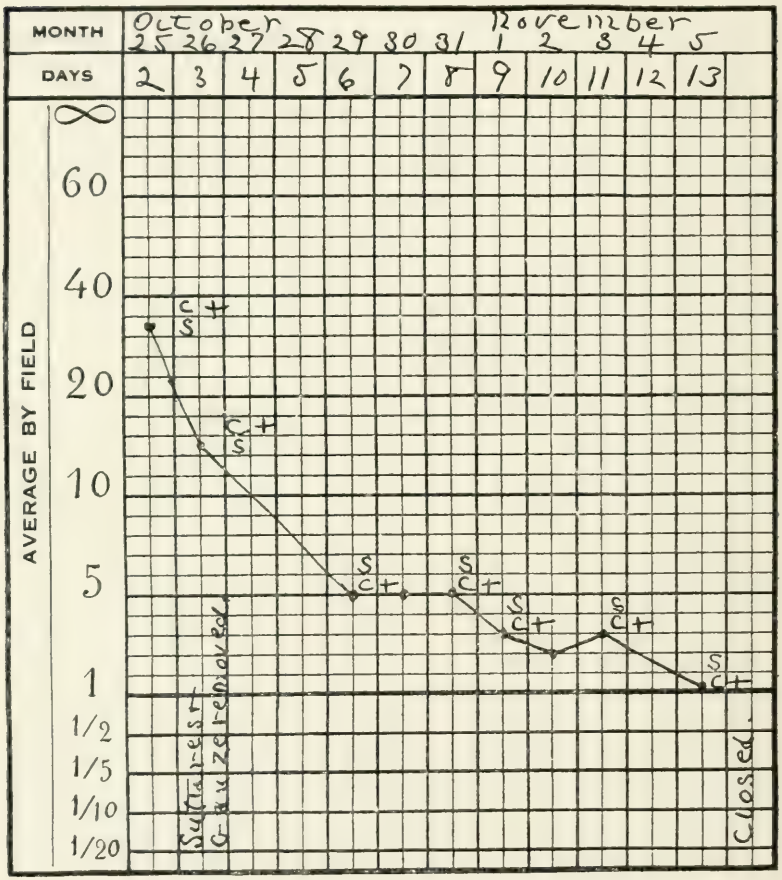
If infection is established about a foreign body it has an extraordinary tendency to persist, and the removal of the foreign body causes this persistent infection to cease. A sinus of months' standing rapidly closes as soon as the foreign body is extracted.

Miss Clarke, at the experimental laboratory of the College of Physicians and Surgeons, has kindly prepared for me a chart which illustrates in a graphic manner the fall in the number of bacteria after the removal of the foreign bodies. These foreign bodies are swarming with millions of organisms; when they are removed the body finds little difficulty in overpowering those that are left.

Foreign bodies, then, are most important factors in implanting infection, and in causing it to persist in the tissues.

After every injury there is a phase of cellular shock; there is a period of time following the injury when there is a paralysis of all cellular activity. It bears a direct proportion to the degree of the initial violence. The defensive power of the cells, their capacity for resistance, are held in abeyance during a varying period. The vitality of the cells is interfered with in some subtle fashion. After an incised wound this period is of short duration. After the violence exerted by hurling into the tissue a jagged fragment of shell casing it is prolonged for several hours. Poincard and Phélip found that wounds examined three or four hours after they were inflicted had the same appearance as those examined a half-hour after the injury. The phenomena of reac-

tion were not only slow in appearing but always of slight intensity. A lowering of cellular vitality with its effect on lessening tissue resistance has been experimentally demonstrated by Roger and



Dog. Infected foreign body removed. Wound closed in nine days.

Josué.[8] They ligated the femoral or iliac artery in ten rabbits, then inoculated their legs with various pyogenic organisms. The controls all showed a small, well-circumscribed abscess. On the other hand, in the animals when the arteries were ligated,

there was extensive swelling of the entire leg and at autopsy all the evidences were found of a diffuse spreading infection.

In every injury there is not only interference with the vitality of cells, but there is cellular death. Here again the amount of necrosis has a direct relation to mechanical violence, and has an important relation to the initial lodgment of bacteria and to their persistence in the tissue. Linser[9] studied the influence of mechanical damage to the tissues at the point of initial lodgment in rabbits. He used staphylococci, streptococci and tetanus spores. He laid the muscle bundles of the abductor bare, then covered them with moist compresses. These animals were used as controls. In a second series of animals portions of the muscle were tied off, or allowed to dry by long exposure to the air or violently crushed. In the controls infection did not take place. In the second series a progressive and fatal infection resulted.

Certain organisms, like the tetanus bacillus and the group of anaërobic bacilli, which produce gas gangrene, are, in a measure, saprophites; that is, they do not gain foothold in the tissue and multiply there unless there is a certain amount of necrotic tissue. Thus aside from the fact that most microörganisms find a favorable medium in necrotic tissue, a group of bacteria are only pathogenic when this medium is present. Moreover, some of these, like the bacillus aërogenes capsulatus, seem to need a special form of necrotic tissue; they flourish only on dead muscle.

That the mechanical removal of all necrotic tissue, especially all dead muscle tissue from a contaminated wound, prevents gas gangrene has been definitely shown, and still more interesting is the fact that the disease can be arrested when established by the resection of the muscle or the group of muscles involved up to a point where the color and contractability of the muscle are normal and the blood supply good. Frankau, Drummond and Neligen[10] a year ago reported a number of cases treated successfully by this method.

In every wound the necrotic tissue must eventually be disintegrated and eliminated before healing can occur, so that the excision of the necrotic tissue along the track of the missile is

only the removal mechanically of material which would eventually slough. The limitation of this removal to 2 mm., as given by certain writers, is obviously misleading. The rule given by Sencert[11] or H. M. W. Gray[12, 13] to cut away the tissue until there is a fresh bleeding surface seems to be generally accepted, for the amount of tissue damage bears a relation to violence inflicted. In an injury from a projectile it must depend upon the mass and velocity of the missile.

The elimination of the necrotic tissue from a wound is brought about to a very limited extent by autolysis. It is accomplished by the energetic proteolytic enzymes furnished by living leukocytes and set free by their destruction. In an infected wound the bacterial enzymes play a most important part in this elimination, but the products of their activity are proteoses, ptomains and a row of decomposition products harmful locally and when absorbed. A morsel of necrotic tissue in an infected wound contains thousands of organisms and it is these nests of bacteria which are so frequently responsible for persistent infection. When they are cast off or removed the wound immediately heals. If one were to count the number of bacteria and chart them from an ordinary boil, I feel sure that there would be a most astounding fall with the elimination of the slough or necrotic core and the base line of one or two to a field would be reached six or nine days afterward. The different tissues have a varying degree of resistance to dissolution; connective tissue, blood plasma, lymph and muscle are rapidly destroyed, aponeurotic tissue and tendons are still less so, and bone is most resistant. Dead bone separated from the living tissue, swarming with bacteria as a focus of infection, may remain for years in the tissue.

Kenneth Taylor[14] has given the bacteriological findings in sequestra. He always found them infiltrated with bacteria. When the sequestrum is removed there is rapid healing, the closure of a long-standing sinus.

Tissue necrosis then furnishes a suitable culture medium for bacteria, permitting them to flourish and multiply in the tissues. Devitalization of cells makes them react slowly. Foci surrounded by devitalized tissue are poorly defended.

In accidental wounds due to the different contractability of the tissue planes and their displacement, there is a tendency toward imperfect approximation of the walls of a wound. Dead spaces are readily formed. Even in operative wounds, if the entire area about the incision is removed and examined after what appears to be most painstaking apposition, these spaces are frequently seen. If hemostasis has been exact they are filled with lymph. In bleeding wounds they rapidly fill with blood. In irregular, lacerated wounds they are much larger and form stagnant pools of fluid in the tissues. Now although freshly shed blood and lymph are bactericidal, this property is rapidly lost. Blood furnishes an excellent medium for bacteria. Dorst[15] has studied this disposition of hematoma to infection; he found that it was increased about forty-fold for the staphylococcus.

Long-continued infection, with imperfect drainage, together with rigid and unyielding scar tissue, frequently causes uncollapsible spaces, which do not disappear when the fluid within is evacuated. Whenever the exudate is removed there is a contraction to a slight extent of the cavity and a tendency to the closure of the orifice on the surface. Then again the fluid collects, the process repeating itself indefinitely until, by some mechanical means, the unyielding wall is obliterated. Such cavities are seen in chronic osteomyelitis. The most striking example is furnished after the imperfect drainage of the pleural cavity. By simply creating different anatomical conditions, by destroying by surgical operation, the infected dead space either by removal of the outer wall, or the unyielding cicatrix holding down the elastic pulmonary tissue, the long-standing infection is arrested, and the old sinus closed.

Dead spaces furnish favorable conditions for the growth and persistence of bacteria in the tissues.

I have presented this paper with a certain diffidence. The reference to principles so generally recognized and so long known seems banal. I imagine the relief afforded and the prompt healing that follows the extraction of a splinter of wood or a sharp piece of flint from a festering wound must have attracted

the attention of men of the stone age. If we could examine the rolls of papyrus from the great library at Alexandria, how many references might we not find to foreign bodies, imprisoned discharges, separation of slough and persistent fistulæ! "Recent ulcers (infected wounds) will be least exposed to inflammation if the matter is not prevented from escaping at the mouth of the sore," wrote Hippocrates, and Celsus in his chapter on extraction of foreign bodies writes, "A third kind of weapon which requires sometimes to be pulled out is a leaden bullet, or stone or some such thing. In all these cases the wound must be enlarged and what is within must be extracted." This is said to be the first mention of leaden bullets; there is no record of the nature of the weapon used for hurling them into the tissues.

I have referred to these principles, however, endeavoring to place a juster emphasis than is sometimes done on the various factors entering into the treatment of infection. All treatment is dependent on these principles; they are fundamental. No one believes, so far as I know, that one can disinfect, with a chemical only, a wound from an artillery projectile. Yet by the application of these principles the excision of all necrotic tissue, the removal of all foreign bodies, apposition so carefully made that there are no dead spaces, the avoidance of tissue tension by exact hemostasis, these grossly contaminated contused wounds are changed into slightly contaminated incised wounds, and many of them may be closed successfully by suture.

In the Surgical Conference of the Allies[18] last November it was said that the disinfection of the wound has passed from the domain of the chemist to the domain of the surgeon. Primary suture has taken the place of secondary suture and has become the method of choice. General Bowlby,[16] in March of this year, pointed out that these principles were first recognized as advantageous for the knee-joint; then for head, lung and abdomen; and finally for the extremities.

If the infection is well established when the wound comes under treatment, here again these are the guiding principles; the foreign bodies must be removed, necrotic tissue excised, sequestra

extracted, every pocket and irregularity laid open to establish drainage. After this is done and the wound flushed by an antiseptic of a certain concentration, for a certain time, and if the bacteria still persist in spite of the treatment Carrel[17] writes they indicate the presence in "the deeper parts of the wound of foreign matter, such as shreds of clothing, fragments of projectile, splinters of bone or morsels of necrosed tissue." In other words, if at the original mechanical operation there has been a failure to carry out these fundamental principles, the antiseptic most rigorously applied is unable to overcome these unfavorable physical factors.

Is a young surgeon about to go to France to treat infected war wounds likely to appreciate the relative importance of the excision of the necrotic muscular tissue about the track of the missile, if he reads that the first stage of treatment consists in mechanically preparing the wound for the penetration of the antiseptic? Is he more likely to have a just idea of the treatment of infected wounds if he reads two hundred pages on the application of the antiseptic and five or ten lines on these fundamental principles? Is there not danger of converting certain of the admirable technical methods into a ritual, and is not the stress on the unessential one of the predominant characteristics of ritual? I am far from depreciating the application of antiseptics, the rough bacteriological control of infected surfaces, the scrupulous cleansing of the margin of the wound, the avoidance of injury to the granulating surface, the study of the rate of healing by the interesting indices of cicatrization of du Noüy, and the importance of avoiding secondary infection.

But the essential factors both in the initial lodgment of bacteria and their persistence in the tissue are the relief of tissue tension and pressure from without; the mechanical elimination of necrotic and devitalized tissue; the removal of foreign bodies; the avoidance of stagnant fluids in dead spaces and the obliteration of uncollapsible cavities. The enormous experience in the treatment of infected wounds gained in this great war has proved this without question.

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DISCUSSION ON THE PAPERS OF DRS. DUNHAM AND MARTIN

Dr. Edward Martin, Philadelphia:

I have but a small addition to make in the discussion of Dr. Lee's paper. I have the highest appreciation of the Carrel-Dakin technic. With a personal knowledge of its enormous contributing value in healing, it, however, seemed to us that it might be too elaborate and require too much apparatus to warrant its use under all conditions, and therefore we set ourselves to finding out if there were not something which could replace it, under conditions of stress, when its technic was too intricate.

When dichloramin-T was first produced with eucalyptol it was not satisfactory; it was too irritating and decomposed too rapidly. Since chlorcozane has been introduced by Dakin and Dunham it has proved absolutely satisfactory, is not irritating and is extremely prompt in its action. So that, on the basis of the work done, the American Shipping Board proposes to introduce this technic in 166 ships and 340 plants. We advise the paraffin loose mesh in either single or double layer placed in contact with raw surface or granulating areas, and the dressing comes off without the least particle of bleeding, no pain and no discharge. We have experimented for some time with this dressing, with controls having two people do the dressings when the wounds are extensive and we have found that by using the parafined gauze, healing is more rapid, granulations are thinner and cicatrices practically unencountered. We have now concluded that this method is so advantageous as to warrant its introduction into all hospitals. There is less time consumed in the dressing and recovery is 25 per cent. more rapid.

Considering dichloramin-T as a disinfectant for the hands, we have in my military class recently studied 50 cases. I have had the hands washed with soap and water, then with ether, then with dichloramin-T. The dichloramin-T is wiped off and gloves put on. At the end of from thirty to sixty minutes, in other words, at the end of an ordinary operative period, with few exceptions, we have found the hands to remain sterile.

Dr. John A. Hartwell, New York City:

I would like to add one word in commendation of what Dr. Walton Martin said concerning the training of younger men, particularly in the fundamental conditions on which the infection depends. The bacteria alone do not constitute the greatest danger, but the bacteria

added to certain conditions of the tissue may cause grave infection. Many of our fellows are having the opportunity of instructing the younger medical officers, but in the instruction being given at the Hospital of the College of New York, I have observed that this conception is not grasped by them to any extent whatever. We have impressed it upon them very strongly. It also illustrates the fact that many cases, sutured primarily, then sent to base hospitals, have not remained clean but have broken down, requiring secondary treatment. The reason is, of course, that they are sutured while infection still remains. It is well known that with high-velocity missiles the damage done to the tissue extends many inches beyond the track of the bullet. Some men examined a kidney, one pole of which had been shot, and they found at the other pole, damage done to the kidney tissue. I have learned that there has now been accepted a general ruling which is that no primary suture is to be done unless the patient can be kept quiet and under observation for at least two weeks. Concerning the relative value of dichloramin-T and the hypochlorite, we have been using dichloramin-T at Bellevue for seven months. We have followed just as rigidly as we could the laws laid down by Dr. Lee; we have changed from eucalyptol to chlorcozane and have followed every detail. We started in with no preconceived ideas, but we cannot get as good results with dichloramin-T and chlorcazane as with the others. Will Dr. Dunham tell us something of the chemistry with reference to the fact that the hypochlorite coming in contact with body tissue is changed from chloramin to dichloramin, and does that still go on as a bactericide? One of the first speakers stated that hypochlorite is destructive to tissue. The hypochlorite will digest living tissue undoubtedly, but, as shown in the chart this morning, it is perfectly apparent if you put fresh Dakin solution of normal strength in a perfectly clean wound, it remains as Dakin solution for about a minute and a half, then suddenly acts as a lymphagogue and reacts with the chlorite and produces the mucilaginous substance which is not Dakin solution. If you wash that off and examine the surfaces you will find them perfectly healthy. I therefore think that a wrong impression is produced when one states that hypochlorite is destructive of tissue. It will destroy tissue if it does not throw out sufficient lymphatic secretions to neutralize it. You cannot use it in the peritoneum; it cannot be used in the undamaged pleural cavity; therefore, when you use it in tissues normally damaged, great judgment must be used as to when you shall use it, how long you shall use it and the amount you shall use.

Dr. Arthur Dean Bevan, Chicago:

I should like to present very briefly my views on the subject, although Dr. Martin has already voiced my opinions. The subject of wound repair is of great importance at the present time and should present itself as an urgent clinical problem to the surgical profession. In deciding upon the best method of handling wounds the recognition of fundamental surgical principles is absolutely necessary. As Dr. Martin has said, the mere superficial use of an antiseptic on a wound is of little or no value. There is this feature to the surgical work of this war, that it is new, that it is startling and that is the demonstrated possibility, during the period of contamination, of thoroughly sterilizing not the field simply of the operation but the wound itself, as has been worked out by the clean-cut dissection and removal of foreign bodies and devitalized tissue, the stopping of hemorrhage, and the actual cleaning out and sterilizing of the wound itself, as one prepares a clean abdomen or limb for antiseptic operation. This sterilization permits of primary suture in a large proportion of cases. This is not only possible but is being done, and will be done more and more all the time provided we can obtain the case during the period of contamination.

After infection starts, little valuable effect can be obtained from any antiseptic. I believe the elimination of that infection depends upon the living action of the cells themselves at the site of the wound, and the sum total of cells that make up the individual and what the surgeon can do is limited to free drainage and good general care.

Take our experience in the past and the three cases presented by Dr. Lee upon the screen. What would happen if after we remove the bullet we provide good drainage and put on a moist dressing of salt solution? The patient would go on to recovery quite as rapidly. Take the osteomyelitis case. What has happened in hundreds and thousands of cases that have been properly handled in the past without any antiseptics of any kind? Splendid drainage, the prevention of closure of the cavity by the introduction of whatever you please. My old teacher, Moses Gunn, used a wax plug where Dr. Lee puts in rubber tubes, and he kept it there until a healthy granulating surface formed. Is not that just what we do today in such cases, obtaining not necessarily a union by suture but a gradual contraction of a large granulating wound, with perfect repair. Therefore, I say we should teach young officers the importance of the great surgical principles that have been worked out, and then, as a piece of experimental work, continue the investigation with antiseptics which, in my opinion, however, are of very little influence in the end-results.

Major Georges Dehelly, Le Havre:

I think that the discussion regarding the treatment of wounds by the use of antiseptics should follow the facts. The impression of the surgeon who uses only ordinary asepsis is that when a wound is opened and no discharge found and the patient is without fever that everything is going well. That is written in every observation, but that is not exact. When we speak about an infected wound we must consider bacteria inside the wound; when we say that antiseptic substances are of very little value in the treatment of wounds we make a mistake, because the surgical treatment, such as the mechanical cleansing of the wound, is only a part of the sterilization, it is not complete; we cannot know what part of the tissue is living and what part is necrotic. We remove what we think necessary and possible to remove, but we leave a part of contused tissue, and therefore, at this time, why not use a substance like Dakin's solution, which destroys the necrotic tissue and at the same time removes the bacteria. The principle set forth by Carrel was that if a wound has bacteria, secretion and necrotic tissue we must remove the secretion at the same time as the bacteria, and for that reason Dakin said it is better to employ chlorin compounds because they combine with necrotic tissue and remove it. We have followed exactly the principles established. What are they really? At first, when we spoke of antiseptic treatment, all the surgeons said surgery is sufficient, if well done, to give a good result. By this they meant the opening and draining of wounds. Never before 1916 did a surgeon say it is necessary to remove every part of the wound, meaning not only the necrotic tissue but all the parts of the wound in contact with the foreign body. It is not absolutely correct to say that surgery alone can produce complete sterilization of the wound. The scientific men who at the beginning said we must protect the living tissue, the phagocytes, were quite right. It is necessary to open wounds and to support phagocytosis. The phagocytes are not always a means of defense, being many times a means of infection. The ingestion of bacteria does not mean digestion. We can swallow food without always digesting it. We know that it is possible to disinfect wounds by mechanical principles but we know also that in an infected wound, when we use an antiseptic, we can diminish the number of bacteria, and this more readily than without it. If I advocate the closure of wounds, it is because I have seen the possibility of satisfactorily sterilizing the wound previously.

Sir Arbuthnot Lane, England:

I have been studying this question for four years and believe that although our knowledge of bacteria has become of great value, it has

also done a great deal of harm. We are always thinking of bacteria. Now I will assume that the antiseptic treatment is good, but the cases seen all through the war are the ones operated so successfully by Professor Wilms. He binds up a knee-joint and from the moment of injury the patient is made to use his leg constantly. That bears out Wright's statement that the previously formed serum in the joint is a germicide, and I think we must consider that suggestion most carefully. I verily believe that too much learning doth make you mad.

Dr. Thomas W. Huntington, San Francisco:

Just a word in regard to the position here taken against the antiseptic method of treatment. I personally went through the early period of modern surgery feeling that I was dependent mainly upon antiseptics. In later periods I depended on the clean wound without antiseptics. But recently, during the past year, I have had a splendid opportunity of inspecting the wounded in hospitals in England, France and Italy, and as I traveled from day to day and week to week I found myself constantly changing my views; I could not settle on a definite policy. I saw splendid work of various types in England and France. When I went to Italy I determined on a final stand. I will tell you briefly of that experience.

In a hospital system near Udine, in Northern Italy, I found 42,000 wounded and in one particular unit of that great system I found 2100 cases of compound fracture. To me it was tragic. Few men have seen an aggregation such as that, and no individual in his own personal experience, whether an ordinary surgeon or engaged in industrial surgery, has ever had such an experience. I spent an entire day in that unit, and in the course of my inspection picked out about twenty serious cases which were removed to the dressing rooms in order that I might see the dressings. As I passed the beds I looked at the temperature charts, and instead of seeing the irregularity which I had expected I found normal lines. In all that 2100 I did not see one single patient who was in extreme pain, and upon inquiring the secret of it, one of the great surgeons of the world said to me: "The secret of our success in the handling of open fracture is the Carrel-Dakin method of infected wound treatment." As I went along I saw the apparatus—three or four beds under one system of irrigation, but there were scores of attendants who were constantly busy in controlling these irrigations. When I got through I said, never again will I discuss whether the antiseptic treatment of open wounds shall be adhered to or not. It established the truth, as it seemed to me, that there are two factors in this method. One is you remove necrotic

infected tissue and fluids that are a hazard to living tissue and the other is, you kill the bacteria and prevent their further ingress into the tissues.

Dr. William L. Estes, South Bethlehem, Pa.:

I want to say a word regarding dichloramin-T. First, regarding asepsis. It seems to me that the old prevailing principles of surgery must hold whenever there is a contaminated wound, *i. e.*, whenever infection occurs. The question is can one get rid of it at once by this type of dressing or must one wait for the exudation. It is my good fortune to have charge of an industrial hospital where we see thousands of crushes, and we thought we were doing well with the old antiseptic method, consisting in the mechanical principles so well described by Dr. Martin, such as surgical cleanliness, drainage, prevention of adhesions and rest. In these modern times it seems to me we are apt to lose sight of the value of rest in the restitution of normal conditions in wounds. That is one thing we have to find fault with in the use of Dakin's method. Without going into the technic brought out so thoroughly by Dr. Lee, I wish to give my experience in the treatment of sixty cases with dichloramin-T. To give an idea what the method will do, I will detail a case of severe phlegmon of the hand in which the whole palmar surface and wrist beyond the annular ligament were infected and inadequately opened; there was a flap which involved the whole palmar surface, half of which was necrotic. The necrotic area was removed, drainage established, and every crypt and cranny of that phlegmon explored, and as far as possible contact was made with all the sinuses with dichloramin-T. In fourteen days the hand was well except for an area 1 cm. long in the center, and this was granulating. I do not believe with any ordinary antiseptic method so marvellous a result could be obtained. Again, a man was wounded by an exploding shell, fragments of which had been driven through the superficial part of his chest anteriorly and posteriorly, he had seven perforations, all of which had some foreign material in them. Treatment was started by the Dakin method, but the wounds continued suppurating and the whole chest was phlegmonous. The sinuses were exposed, packed with dichloramin-T gauze and in ten days all were closed except for the granulation around the edges. I doubt if these results could have been obtained by the older methods or even by the Dakin treatment. Another case was a crush of the leg, caused by some heavy machinery falling on the extremity; it involved not only 6 cm. of the middle of both bones of the leg, but all of the soft tissues, with severance of the anterior tibial and the interosseous artery, and

only the posterior tibial artery remained, the anterior nerve also being cut. I have found in these large crushes one of the weak points of dichloramin-T; it is almost impossible to get contact with every part of the wound; however, I tried it in this case. I made perforations through the intermediate tissue to the bones, took out the particles of bone and plated the bones together, and after clearing out all the detritus and sloughs and trimming the muscles I put the gauze, thoroughly saturated with dichloramin-T, in every one of the crypts and crannies that I could reach. That man never had a bacterial count over twenty-five to the field and no fever. The tissues healed remarkably quickly, and four months later he left the hospital with an ununited fracture and all the soft tissues well, with good use of the foot and toe and with the least fibrous tissue I have ever seen in such a case.

As a sequel to this case I should like to say that I saw this patient a short time ago when there was necrosis of the ends of the bones, which had been plated. These were removed and the cavity will no doubt fill in in a very short time.

Dr. Charles L. Gibson, New York:

Last year it was my fortune to read a paper before this Association, and among other things I then said, the Carrel method is not perfect, it can never replace good surgery; Dr. Carrel has made no such claims. His book states distinctly what should be done to prepare the wound by the proper application of the antiseptic in order to get good results. He acknowledges that unless one can bring about a state of prophylaxis one is relatively helpless when the patient is infected. The aim is to remove every bit of damaged or badly shocked tissue, and it is only by such removal that one obtains absolute prophylaxis against infection. I do believe that the Carrel method is one of the greatest aids to good surgery. I want to impress the fact, however, that the Carrel method is a very definite and well-planned one, and if one step in the procedure is omitted this will show in the result. I have seen most extraordinary technic used and given the name of the Carrel method.

Dr. Alexander Primrose, Toronto, Canada:

Dr. Bevan has spoken of the vitality of the tissues and others have placed a great deal of importance upon the application of the antiseptic to every portion of the wound surface. Both of these factors are important. There is one phase of this subject which has not been referred to, and that is the physics of the surgical dressing. I have

been very much interested in this for some years since I first learned of a series of experiments, undertaken, I think, in the Pasteur Institute. A portion of the skin of a rabbit's back was shaved, and, over an area of a square inch of surface, the skin was excoriated. Strychnin was placed on this area in powder form and a piece of oiled silk applied to exclude air and prevent evaporation. This dressing, in fact, favored absorption and the animal died of strychnin poisoning. If, on the other hand, a layer of absorbent cotton of gauze were placed over the strychnin and the oiled silk omitted, no poisoning effect resulted. Similar results were obtained with pathogenic bacteria. Other experiments similar in principle illustrated the fact that a surgical dressing may promote absorption into the tissues or may be constructed to favor absorption into the dressings and evaporation from the surface. In Salonica, we had a large number of wounded, brought from the front from certain localities, where the system was in vogue of wrapping wounds in oiled silk. These gave a beautiful opportunity to experiment. I removed this dressing, cleansed the wound, put on sterilized gauze, and under such simple treatment, all the swelling subsided, the redness disappeared and the wound healed. I repeat that it is an important matter in developing our technic, to pay special attention to the laws of physics in constructing our dressings. I have looked with some degree of anxiety upon the introduction of the paraffin gauze for wound dressings because the ideal dressing is not an impermeable covering but one that permits of absorption into and evaporation through its substance.

Dr. Alexis V. Moschcowitz, New York City:

As already stated in the discussion of Dr. Hartwell's paper, I am now a most ardent advocate of the Carrel-Dakin treatment. Similar results cannot be obtained with any other technic or antiseptic. There is, however, a right way and a wrong way to carry it out. In order to obtain good results it is important to follow out instructions to the minutest detail.

Major E. K. Dunham, New York City:

I think there is no question about the efficacy of antiseptics. They are simply a means of accomplishing a fairly definite and precise thing in conjunction with other procedures. I tried to define the limitations in their uses by calling attention to the necessity of contact, mass and time. If there is failure to secure contact, disinfection will not be obtained; if the antiseptic is not present in sufficient amount, there will be no result; also if not in contact for a sufficient time. In the

mechanical cleansing of wounds by surgical means there is an element of skill just as there is in the use of an antiseptic, and both in the final analysis depend upon the active coöperation of the tissues of the patient. You are depending really upon their recuperative powers, in the ultimate analysis, to restore defects, but it does seem possible that some of these antiseptics would cover that little margin of uncertainty that exists after a surgeon has attempted to cleanse a wound by mechanical means. Then, as an adjunct, the antiseptics have a distinct field and a definite value. It may be possible in some cases to avoid an extensive mutilation by operation if one intelligently and in a conservative spirit relies a little upon properly applied antiseptic methods.

There were some questions asked upon which I can express an opinion. One was the relation between the proteins and sodium hypochlorite. The sodium hypochlorite does convert some of the amino groups in the protein molecules into chloramins. These chloramins have an antiseptic action; they are, however, unstable and in the course of time the chlorin atom attached to nitrogen in the chloramin group passes into combination with carbon, and this combination is stable and completely inert as an antiseptic.

In regard to the self-protection of the normal tissues, that depends largely upon the pressure of tissue fluids, especially those containing protein substances, and especially blood. The greatest irritation is where there is no protein secretion, the skin being a familiar example of a tissue suffering irritation.

In the treatment of empyemas there are many cases in which it is impossible to do mechanical cleansing, and these cases do exceedingly well under treatment with the chlorin compounds, particularly with Dakin's solution.

If neglected or allowed merely to drain they will go on for three or four months without healing, but even then these chronic cases may often be quickly alleviated by a thorough use of these antiseptics. Since this is true, why not make use of these antiseptics in cases where surgical cleansing is not, or only incompletely obtainable by mechanical means?

Dr. Walter E. Lee, Philadelphia:

I feel that I neglected, in starting my paper, to say there is little common ground on which we all agree today and upon which we started as an hypothesis in the study of germicides. One should not depend upon a chemical agent to perform in the treatment of suppurating wounds that which can and should be done quickly and thor-

oughly by mechanical means. Neither chemistry nor bacteriology can or should be expected to replace the mechanisms of surgery. At the best these chemicals can react only on the tissue with which they come in contact. Therefore, devitalized tissue must be removed by mechanical means. Hypochlorite in concentration of 0.5 per cent. is not destructive to tissue. By putting a living tadpole tail into an 0.8 per cent. solution of hypochlorite the tail was eaten away; another was put into a 0.48 per cent. solution of hypochlorite with no effect; the tadpole was then killed and the tail allowed to remain in the hypochlorite, with the result that there was immediate decomposition. In 0.45 per cent. solution there is no destruction of living tissue. I was interested in Dr. Primrose's remarks, as we have been criticized in the use of oil because of Latery's use of boiling oil as an antiseptic.

Dr. Huntington's reference to his visit to the Italian Front has been extremely interesting. After two years in a French base hospital, where we could see the end-results coming from both English and French surgeons with the use of Wright's germicide acid to pure carbolic acid, then back to soap and water, there was no doubt in the minds of men who worked there that the wounds treated with antiseptics and having exactly the same surgical treatment did better than when no antiseptic treatments were used.

Dr. Walton Martin, New York City:

Captain Lee has expressed so well the advantages of antiseptics in the treatment of wounds that I wish only to express my agreement with him. We all admit there are two factors in the treatment of infection. First, there is the necessary surgical intervention, and, secondly and subsequently, the application of an antiseptic, and in the application of this antiseptic I believe the technic of Carrel to be the best. The point that I have wished to emphasize is the relative importance of these measures. Statistics given out by Dr. Depage seem to me very significant and interesting. For a year in gunshot injuries of the knee he used the Carrel system, that is the introduction of Dakin's solution through small tubes at regular intervals after the joint had been cleansed mechanically and the projectile and all foreign bodies removed. Since July, 1916, after the excision of all of the tissue about the path of the missile and the removal of all foreign bodies, he simply sutured the synovia and introduced no antiseptic. The recoveries with restoration of movement under this treatment have been 80.36 per cent., under the Carrel system 40 per cent. Under the Carrel treatment in 15 per cent. amputation of the thigh was necessary, some were performed during the period in which

reliance was placed solely on mechanical cleansing. Later, Dr. Depage published a report on the secondary suture of the wound in cases of open fracture. By rigorously following the Carrel method he had been able to close the wounds in from fifteen days to a month. In other words, in compound fractures he had secured most satisfactory results if after mechanical cleansing he had used an antiseptic. The explanation seems to be obvious. In the knee-joint the track of the projectile is short and its complete excision is possible; moreover, the joint is irritated by drainage tubes. In compound fractures the bullet track is often complicated and its complete excision is difficult. Even after mechanical cleansing Dr. Depage preferred to supplement the treatment by chemical measures.

SURGICAL CLOSURE OF WOUNDS

By GEORGES DEHELLY, M.D.
LE HAVRE, FRANCE

The surgeon, considering the diverse methods which present themselves to his initiative in the treatment of war wounds, must give first consideration to the prevention, control or treatment of infection. The basis of all these methods is the surgical treatment, and since the beginning of the war, surgeons have given it first place. But how chaotic the theories were, how insufficient the surgical treatment applied by those who had the most absolute confidence in it!

I shall not speak about the treatment applied in the early days of the war. This treatment was based on the belief in the asepsis of war wounds, and the treatment recommended by the chiefs of military surgeons was expectant treatment.

Immediately after the battle of the Marne the deplorable results of this expectant treatment showed that war wounds were almost all infected, and that in order to avoid grave infectious complications it is necessary to open the wounds widely, as quickly as possible, to remove foreign bodies and to drain the wounds. This treatment improved results considerably, suppressing, to a great extent, the serious infectious complications; but, though considered sufficient by a majority of the surgeons, it did not suppress infection completely. Cicatrization of wounds, often even insignificant, was brought about in thousands of cases only after five, six or seven months of dressing.

Carrel and Dakin thought that something better might be obtained and that the rational application of a judiciously chosen

antiseptic would permit sterilization of these infected wounds and shorten considerably the time of cicatrization.

Having charge of surgery in the hospital at Compiegne, annexed to the laboratories of the Rockefeller Institute, I was quickly able to demonstrate the possibilities of this sterilization, and after four months of research, in August, 1916, I attempted, with my collaborator, Dr. Joseph Dumas, the surgical closure of wounds treated after the principles developed by Carrel and Dakin. In October, 1915, we arrived at the following conclusions:

Every wound treated by the Carrel-Dakin method within a short time after the injury, and containing no more than one bacterium per four or five microscopic fields, can be closed without drainage. And since that time 90 per cent. of all kinds of wounds treated in our hospital were closed before the twelfth day. Consequently, we were able to assert that if sterilization of a wound must be the first step of this treatment the surgical closure must be the second step, no less indispensable to maintain the disinfection and to avoid all ill effects of a spontaneous cicatrization.

A majority of the surgeons followed us in this path, and if all did not seek sterilization by the Carrel method they were obliged to adopt a part of the technic, and the bacteriological examination of wounds, initiated by Carrel, remains the only solid basis of a rational treatment of wounds.

In 1916 Gaudier recommended that the first operation permitting the excision of the walls of the wound containing necrotic tissue and bacteria can be followed by primary suture if done within the first eight hours after the injury. The improvement in surgical treatment brought about by the complete mechanical cleansing is able alone in a certain number of cases to ensure sterilization, and suture can follow immediately upon the heels of this mechanical cleansing to ensure the maintenance of the sterilization. However, this primary suturing is sometimes followed by serious accidents, such as gaseous gangrene, diffuse phlegmon or streptococcemia.

The last report of Tuffier and Saquepee to the Surgical Inter-

Allied Conference shows the necessity for finding a test giving the limit for primary suture.

The defect in the technic, claimed by Gaudier, is the impossibility for the surgeon to ascertain whether or not he is able to close the wound without accident after a surgical cleansing. This technic is still empirical and the necessity of including in it the bacteriological examination is shown by the number of researches published in this direction.

Duval, to avoid the grave failures of the primary suture, used to keep all the wounds open with an aseptic dressing and to delay the surgical closure until the results of the bacteriological examination were known. This procedure was based on the findings that 77 per cent. of wounds thoroughly operated within the sixth or seventh hour after the injury remain sterile under aseptic dressing. In fact, the other 23 per cent. are about the percentage of failures in primary closures. And following this technic, Duval escaped the serious complications from primary sutures.

Gross and Tissier, in March, 1917, claimed that the presence of streptococci must decide the reopening of a wound closed primarily. In other words, they think that serious complications will only arise from the closure of a wound containing streptococci. They did not say that it is impossible to suture a wound having streptococci, but that when a wound is sutured primarily, a bacteriological examination having been made at the same time if streptococci develop in the culture it is necessary to remove all the sutures. There are several errors in this point of view:

1. The streptococcus is the most important cause of failure, but it is not always a cause of failure. There are examples of successful sutures of wounds containing streptococci reported in the work of Tuffier and Saquepee.

2. The streptococcus is not alone a cause of failure. The anaërobic bacteria and virulent staphylococcus are often causes of infectious complications.

Levaditi, working with Depage at La Panne, studied the bacteriological evolution of wounds and formulated rules based on this evolution. Levaditi says that in the first period—during

twenty-four or forty-eight hours if the bacteria are virulent they are growing fast. In this case it is impossible to close with any kind of bacteria. If the bacteria are not virulent it is possible to close, providing they are not streptococci or Welch bacilli.

In a second period if a wound is not closed after the first period of equilibrium between the organism and the bacteria the bacteria adapted in the wound can grow, the equilibrium being destroyed in their favor. This is the period of acute inflammation during which, progressively, the organism is increasing its means of spontaneous defense. In the third period these means of defense are stronger than the attacking power of the bacteria, the development of the bacteria is arrested, and their virulence diminishes progressively.

During the second period, or period of acute inflammation, it is impossible to suture a wound, but during the third period, or period of diminution of the virulence of the bacteria, Levaditi says that it is possible to close a wound even if the bacteria are numerous, provided they are not streptococci or gas bacilli.

To sum up the conclusions of Levaditi: There are three periods in the evolution of the bacteria in a wound:

1. In the first period we must resort to secondary suture early (within twenty-four or forty-eight hours after the injury) in the case of a wound which has been widely opened and treated by the Carrel-Dakin method, and which is known during the first hours to be sterile or but slightly infected by other bacteria than streptococci or gas bacilli.

2. In the second period we must apply the Carrel-Dakin treatment and await *la crise*.

3. In the third period "it is unnecessary to wait until the bacteriological chart reaches the zero point to close the wound, provided that these bacteria were attenuated and not streptococci."

But to apply these rules it is necessary to employ a bacteriological examination more complete than we did.

Levaditi says that the cultures are the best index of the quality and the virulence of the bacteria, employing at the same time smears to measure the quantity of germs.

The delayed secondary suture makes slower progress, because it is more difficult to be certain of the bacteriological condition of the wound in the granulating tissue. In this condition technic is still hesitating and the failures numerous. These failures are due to the granulating tissues which grow during the suppuration. Every granulating wound treated aseptically cicatrizes, retaining in the scar tissue numerous bacteria. These bacteria possessing attentuated virulence are, nevertheless, susceptible of renewed vigor, especially at the time of an operative traumatism, such as may be necessitated by a secondary closure. It is for this reason that it is essential to diminish the infection and to treat it as early as possible. If primary suture has not been accomplished, through impossibility or failure, it is necessary to employ immediately an antiseptic method by means of which cicatrization may be accomplished without latent microbism.

It would be, indeed, a great mistake to accept as axiomatic that the primary closure must take the place of all the others. It is evident that where it is possible to practise it without danger to the patient it is of considerable benefit. But we must not forget that this procedure is possible only in certain periods of warfare: When the wounded are not very numerous—that is, if an attack is to be made on a short part of the front—it is possible to forecast the number of wounded and to provide the necessary surgeons. But as soon as the number of wounded increases, due to the extension of the front or change to open warfare, it is impossible to perform the complete operation close to the front line. It is then necessary to do only the minimum: only to open the wounds, only to do hemostasis and to send the wounded to the rear. Here we find again infected wounds at the acute period, and it is necessary to treat the infection before secondary closure. Thus one will see that the impossibility to complete the surgical operation at the front is not confined to times of retreat, but may happen even with an advance. During the battle of Flanders last fall the British were compelled to follow this rule. The wounded, hastily operated on at the front, reached the base hospital in suppurating condition. I was able to verify this fact at the base

hospitals of Rouen, where the American units from St. Louis and Cleveland were working.

We must not be asleep with too great an optimism and believe that infection is overcome.

Great progress has been made since the simple opening and drainage of wounds to their complete excision and closure. But these primary and secondary closures are not always performed under the best conditions. We lack, even now, an effective test which will indicate, after an operation, whether the wound contains virulent or non-virulent bacteria, and whether or not we can safely close it.

Technic. I will not burden you with a very detailed technic for the surgical closure of wounds. It is done without special precaution when it is done early. I wish only to call attention to some new facts. Whatever may be the procedure employed the following precautions must be observed.

1. The closure must be as nearly complete as possible. If the suture is not complete there is reinfection from the exterior, generally from the skin.

2. The stitches should be without exaggerated traction. Tension of the stitches puts the skin in bad condition of defense against infection.

3. Under the cutaneous suture no cavity must be left in which secretions can accumulate. The secretions accumulated in the cavity constitute a very good medium for the culture of the bacteria. There is, however, a procedure which banishes complications when suture is not absolutely complete or if there is reason to fear a hematoma (the hemostasis having been difficult) or if there is any oozing whatever. This happens often in the secondary closure of stumps with resection of scar tissue and bone ends. In these cases cutaneous suture is made as complete as possible, but one or two instillation tubes are left under the skin to sterilize the subcutaneous cavity by the Carrel-Dakin method without the necessity of removing stitches, if there is some inflammation after the operation.

These divers rules must be more strictly applied in the suture

of old wounds made after a long period of suppuration. Indeed, the granulations contain bacteria (now attenuated but liable to be increased by the traumatism), and it is necessary to avoid the possibility of a new suppuration which would prevent success of the suture. Besides, these granulating tissues have made the walls of the cavity in the muscles rigid, and the suture of the skin will be insufficient to efface this cavity. Furthermore, the skin is extremely retracted and the surgeon is unable to close the wound completely without too great a tension of the stitches. We must then have recourse to a very simple procedure—namely, the corsetage of the wound for forty-eight hours before the operation.

This consists of the application on each side of the wound of adhesive plaster, along the edge of which, at intervals, are hooks. A rubber string laces this, thus bringing together the edges of the wound. Retraction of the skin is easily overcome, and in twenty-four to forty-eight hours the edges are in contact. The more or less intramuscular cavity is thus effaced, and it becomes possible to suture the skin without having to act on the granulating tissues wherein infection is most to be feared. To effect the suture it is sufficient to resect the epithelial line, to raise the edge of the skin 1 or 2 centimeters and to stitch after a precise joining of the edges.

Sometimes the granulations are so thick that it is better to curette them to diminish the thickness of the scar. In these cases I prefer to operate twice: (1) surgical resection of the scar, followed by sterilization with the Carrel-Dakin treatment; (2) closure, several days later, after sterilization.

I had to treat a great number of extensive streptococcic phlegmons in Roumania last winter, which plegmons I was able to sterilize by the Carrel-Dakin method and to close through the medium of an elastic corsetage. These closures were made in one step in those cases which were under my care from the beginning in two steps where the sterilization was begun after a long period of suppuration.

Another difficulty may be encountered by the presence of a bone cavity, in order to close which it is necessary to begin filling

it before the closure. We employed several procedures to fill these cavities, using several kinds of paste or transplanted fat-grafts. A new procedure recommended by my associate, Dr. Guillot, seems better than the others. It consists of closing the cavity with a flap of skin to which is adherent and appendant a flap of subcutaneous fat, the fat filling up the cavity, which is covered by the skin, sutured at the edge of the wound.

There are, however, some cavities that we can close without filling. These are the joints and the pleural cavity. The articular cavity is made to be permanent and the pleural cavity will be quickly effaced by the spontaneous extension of the lungs. We had this winter considerable experience with streptococcic empyema, and all the cases treated before the period of rigidity of the walls of the infected cavity were successfully closed.

I do not wish to prolong these details. I wish only to call attention to the fact that if we have made any progress in the treatment of infected wounds it is because surgery has discarded empiricism, becoming more scientific through the acceptance of help from other sciences, such as biological chemistry, bacteriology and mathematics.

The time is past when the appearance of the wound and the temperature chart were sufficient indicators to the surgeon of the evolution of a wound. Something else is necessary. The bacteriological chart of Carrel and a complete bacteriological examination must enter into the practice. An antiseptic substance must no longer be judged by the color it imparts to the wound, but according to the real effect on the secretions, on the dead or living tissues and on the germs which contaminate it.

It is just to say that this evolution of surgery has been guided by the work of Carrel and Dakin.

DISCUSSION

Dr. Charles L. Gibson, New York City:

I want to back up the statement made by Dehelly about the closure of wounds. It was my privilege, in 1916, to visit Carrel at Compiègne when his work was well established. I had never seen anything comparable to this work before. I soon realized that perhaps the one greatest single element in Carrel's work was Major Dehelly, because he was doing the very best surgery. I got a letter from Carrel in which he said, "I have some remarkable things to show you. We have entirely suppressed suppuration." I was skeptical, and said he was not a surgeon but primarily a laboratory man with no practical experience on the subject. I came away absolutely convinced, however. One of the things which particularly impressed me was the absolute comfort of the patients when the wounds were dressed. It is remarkable to see the indifference of the men to the dressing of these compound fractures. Apparently they are quite free from pain. Dehelly told me that in a series of 400 cases he had only six minor mishaps, and that he and not the method was to blame, as he had closed them a little prematurely. An interesting factor was the absence of all reaction. The wounds impressed me as if one were illustrating an operation on the cadaver when for the sake of appearance he sewed up the wound. Upon feeling of these wounds there was no sense of infiltration—they were absolutely devoid of scar tissue. I have never seen anything like that before. In my opinion this method is a distinct step forward in the treatment of wounds. I think the method which is today coming to the front has its place and its reservations just as the Carrel method. The question is now, Under what conditions can we best employ one or other methods, since we must consider the elements of time, of care and of military circumstances? I do believe that if a patient can come under observation at an early stage, less than eight hours, under the care of a good surgeon and in proper circumstances, that the method of excision on the whole will give the best results. There is no question but that one gets good results by excision and some cases require an enormous amount of surgery with some disability. The question comes, Can we compromise between the two, a partial excision of the wound and then utilize immediately the Carrel method as a further prophylaxis?

Dr. Thomas W. Huntington, San Francisco:

My remarks are suggested by Dr. Gibson. It was my good fortune to have seen the work in a very large number of the European hospitals

last summer. To give you some idea of the value of work, we visited cities, Florence for instance, where we were told there were 25,000 beds and 20,000 wounded; in Milan there were 17,500 beds and 15,000 wounded. The thing that impressed me was the great comfort of the patients. Their facial expression indicated no great distress; they were smiling and most of them smoking. I scarcely saw, in all my experience, a single septic case such as would have been common twenty to thirty years ago.

The wounds were such as are never seen in private life. Some were ghastly beyond description. In one case four inches of the shaft of the femur was carried away with terrific destruction of the soft parts, and yet the patient was lying in comfort, with normal temperature. I do not mean to say that any particular method was responsible for this, but I did notice that wherever the Carrel-Dakin treatment was used there was a very notable absence of trouble. Furthermore, I was told repeatedly that where it was not used it was simply because they could not obtain it. There was a great dearth of rubber material and in some places it was impossible to get chemicals with which to prepare the solutions. The whole experience was to me a very novel one in contrasting the tremendous wounds and the apparent comfort of the patients.

IMPROVEMENTS IN RECONSTRUCTIVE SURGERY OF THE HEAD

By JOHN B. ROBERTS, M.D.
PHILADELPHIA, PA.

The frequent deformities, due to gunshot injuries and burns in civil and military life and those developed in the scars of operative mutilations, claim surgical attention. Variation of detail inures in the plastic repair of lesions of different regions of the body from the causes mentioned. Nevertheless, the principles of the surgeon's reconstructive work and the steps, through which the organism responds to his desires, are essentially the same in head, trunk and limbs. An ignorance, which often causes surprise, still exists in the minds of some as to the usefulness of treatment for cicatricial deformity of the face. This lack of knowledge of recent progress in operative surgery appears not only in rural populations but is constantly exhibited by dwellers in large cities.

Congenital malformations, like hare-lip, cleft-palate, webbed digits and cicatricial distortions from slow healing of burns and crushing injuries appear at metropolitan hospitals for treatment months, even years, after the precious early moment for corrective surgery has passed.

Appreciation of the value of prompt plastic aid is gradually being instilled into the minds of surgeons by the lessons of the present European war. The energy exhibited by the contracting force of fibrous tissue, when it replaces granulation tissue in wounds is astonishing. Carrel and de Noüy have shown that when open wounds are compelled by infection to heal through the

conversion of granulation tissue into scar tissue the major part of the closure is effected by dragging the boundaries of the ulcer toward a central point. Thus it is that the epidermization is reduced to a minimum and the cutaneous defense against ingress of microörganisms reëstablished. The effect of this interstitial contraction, however, on the surrounding and underlying structures is lamentably evident. Slow healing of wounds or ulceration after operation or separation of dead tissues may cause eversion of lips and eyelids, closure of orifices, strictures of ducts, adhesions that restrain the movements of joints and even lead to dislocation of fingers and toes.

Reconstructive surgery is simply a part of general surgery, which has been developed by a study of Nature's methods of repairing wounds and the adoption, by the surgeon, of such mechanical aids as will further the recreation of normal contours and reëstablish prior functions. Its object, in the main, it may be said, is the construction of absent or lost parts and the reposition or curtailment of parts displaced or deformed by injury or disease.

The deformities which it is designed to correct may be grouped as those due to:

1. Imperfect fetal development, such as webbed fingers, cleft-palate, supernumerary digits.

2. Ablations of tissue, as in war wounds and operations for injury or malignant disease.

3. Ulceration or necrosis, as in urinary and salivary fistule, occlusion of orifices, stricture of canals, loss of portions of the skeleton.

4. Contraction of scar tissue, causing adhesions about joints, eversion of lips and borders of orifices, fibrous ankylosis of articulations.

5. Overgrowth or irregular contour, as in gigantism of nose and ears, flaring ears and adipose overgrowth in abdominal wall.

6. Conversion of rigid structures into movable ones, as in bony ankylosis of joints; and flaccid structures into rigid ones, as in operations for non-union of fractures.

Recent developments have taught that nearly all tissues can be repaired by plastic procedures if the operative technic is mechanically efficient, provided that the wounds be kept aseptic from the moment of their production to the end of the period demanded by Nature for the metabolic reëstablishment of function. The functional repair may be inferior to the original status of the parts, but reëducation of the patient's mind, nervous system and circulation accomplish in time wonderful increase of efficiency. The change of a slender graft of bone, placed between the epiphyseal ends of the tibia after necrosis, into a thick weight-bearing column seems nearly miraculous. The return of sensory and motor function to fingers after nerve-grafting in the arm almost resembles the raising of the dead. Under some circumstances a failure to maintain an aseptic condition of reconstructive wounds does not imperil the ultimate result very much. It does, however, prolong the time of recovery. This statement is applicable especially to osteoplastic operations.

The patient to undergo operation should be in good health, and the tissues, with and upon which plastic operations are to be done, should be free from local deterioration. The operative field and technic must be aseptic and the after-treatment should maintain a similar freedom from infective agents. The great adversary in plastic surgery is bacterial infection; the other enemies of success are tension on sutures and too early disturbance of the repaired tissues. Meddlesome inspection by unskilled assistants is a great danger. The surgeon usually will do well to permit no early mobility and prohibit any one but himself or a trained coadjutor looking after the dressing of his operation wounds. The prolonged fixation is of preëminent importance in bone grafting of fractures, except perhaps in mandibular reconstruction.

The methods of plastic surgery are:

A. Displacement:

(*a*) Approximation, as in hare-lip.

(*b*) Sliding to transfer tension, as in ectropion.

B. Interpolation:

Borrowing material from vicinity, from another region, or from another person or animal.

I. Transferring flap with pedicle.

(*a*) At once.

(*b*) By successive migrations.

II. Transportation with pedicle:

(*a*) Direct from hand or arm.

(*b*) Indirect, by using hand as carrying agent.

III. Transplanting without a pedicle (grafting).

C. Enthesis:

Burying in the tissues foreign bodies, such as paraffin, wire, metal, glass, rubber.

D. Retrenchment:

Cutting out ellipses or wedges, as in gigantism of ears and nose.

E. Substitution:

Cecum for bladder, bowel for vagina, appendix for urethra.

F. Strategic:

Temporary displacement, as mandible to get at pharynx; zygoma and cranium to reach brain.

Operative Steps:

In simple procedures:

1. Freshening edges, and cutting away fibrous scar tissue if new tissue is to receive bloodvessel connection therewith.
2. Obtaining flaps if necessary.
3. Arresting bleeding.
4. Adjusting parts in proper relation without tension; with sutures, tacks, staples, Michell clips.
5. Closing gaps left by cutting out flaps.
6. Dressing wounds aseptically, and keeping them aseptic
7. Preventing too early motion and undue handling of tissues reconstructed.

In complicated procedures:

May need a series of operations extending over months. Each operation forms a basis for the succeeding one. Do not attempt too much at once. Allow time for healing and contraction.

METHODS OF PLASTIC SURGERY

A. Manner of making cutaneous flaps with pedicles.

Make pediculated flaps large, thick, with good vascular supply through wide pedicle.

Artery and vein may be in flap or partly denuded of skin.

Subcutaneous fascia must be included.

Because skin when cut loose contracts, make flap 30 to 40 per cent. larger than opening to be covered.

Freshen edges of gap to be covered by cutting away fibrous cicatrix before making flap.

Make flap to have cardiac end, with artery running into its base.

Long axis of flap should correspond with direction of arterial supply.

May neglect this rule if anastomosis is free.

May be well sometimes to cut flap and wait a few days before stitching it in place.

Do not twist pedicle so much as to close artery or vein.

Do not impede arterial supply or venous discharge by tension.

If either event is evident on second day, take out stitches to restore arterial current, or puncture flap with deep incisions to lessen venous engorgement.

Injurious tension may be relieved by making pedicle with curved or angular borders.

Stop hemorrhage before applying pediculated flaps and lay them in place loosely, not in a stretched condition.

B. Manner of making transplants (or grafts).

Tissues must be aseptic, not antiseptic.

Grafts must be aseptic and not injured by mechanical or chemical irritants.

Sterilize surfaces to be grafted and surfaces from which grafts are to be obtained, if not already sterile.

If antiseptics have been used, bathe surfaces with sterile normal salt solution.

Keep grafts wrapped in dry gauze at operation.

Carrel uses grafts kept in cold storage for long periods.

Pieces of skin, nerve, fascia, fat, tendon, cartilage bone may be used as grafts.

Skin grafts of whole thickness should have adipose tissue clipped off.

Place graft in contact with like tissue where gap exists.

Hold graft in place by pressure or sutures.

In skin grafting press out air under graft.

Dressings:

Mild antiseptic solution may be painted along wound if pediculated flaps used.

No antiseptics may be used with transplants (grafts).

Dry gauze dressing, aseptic, of course.

Perhaps warmth by dry heat outside dressing, when blood supply is doubted.

Keep wound quiet and do not disturb dressings early or often.

Do not uncover wound earlier than fourth or sixth day, if free from contamination with saliva, or mucus from mouth, nose or eye.

Face wounds will often do very well without any gauze dressing. I usually prefer none, or but a *single* layer of dry gauze.

Results:

Pedunculated flaps, or grafts that remain healthy for four days are not apt to slough.

If within this period flap or graft becomes grayish, pulpy, and shows loosened cuticle, venous gangrene is probable.

If, however, it becomes whitish, then dark and withered, arterial gangrene is probable.

If gangrene seems imminent, it is possible that only an upper layer or the edges will die.

Hence do not cut away slough too hastily.

In arterial gangrene, take out sutures that seem to cause tension even if you separate the whole flap except pedicle.

In venous sloughing, scarify and puncture the tissues of flap and also relieve tension of pedicle by cutting a few sutures or untwisting pedicle.

The innumerable head injuries of the present war and the energy of military surgeons who have been brought into contact with these traumatisms have given a great impetus to the study of reparative surgery of the head. In the civilian school of plastic and oral surgery, established by the Surgeon-General of the Army at Philadelphia, marked interest was at once evident in the laboratory practice of this branch of reconstructive surgery. Old methods were made familiar to the younger men; new ideas and procedures penetrated the indurated brains of those who were older. As must always be, we the seniors have been greatly impressed by the progress in plastic surgery developed by men of less age than ourselves. To call attention to some of the new ideas in plastic surgery of the head and to set down some of the opinions, which war surgery has crystallized in the minds of men, is the chief object of this paper.

Surgeons have been taught to realize that important elements in the treatment of war injuries are prompt readjustment of tissues and immobilization. In gunshot fractures of the mandible, for example, prompt immobilization and restoration of a relatively normal dental occlusion have been accepted by general and dental surgeons as factors of great moment. Instances may arise in fractures with loss of bone which justify coaptation and fixation of the ends of the remaining fragments with forfeit for a while of the proper occlusion of the remaining teeth. These injuries are not as common as those in which temporary interdental splinting to fix the fracture and maintain an approximately normal bite will be more advantageous. A large proportion of mandibular fractures in war are not only comminuted but also contaminated, and probably already infected when seen by the surgeon. Prompt fixation of broken bones in the limbs has long been an axiom of general surgery. The rule applies even

more rigidly to comminuted and open fractures, sure to become infected, in the oral region. Hence fixation before transportation applies to gunshot fractures of the lower jaw bone. While it is true that the constant flow of saliva and the ease of establishing submental drainage by incision usually will lessen the violence of septic complications in mouth injuries, it is almost obligatory that embedded foreign bodies in the floor of the mouth and the neck be immediately removed to avert infection. The term foreign bodies includes bullets, shot, shrapnel, pieces of clothing or shell-casing, gravel, displaced teeth, and small unattached splinters of bone. Large pieces of bone covered with periosteum should not be disturbed, but replaced as accurately as possible.

Early reconstruction of the skeletal foundation of the face is an important factor also in maxillary and nasal fractures. For this purpose, general anesthesia may sometimes be demanded. It is securable with nitrous oxide gas or the primary anesthetic effect of ether. Conductive anesthesia with cocain or novocain may be sufficient. Early excision of contaminated structures followed by immediate and loose suturing of wound edges will often be followed by early healing. As the bones of the face in uninfected fractures unite quickly, prompt restoration of bony contour should be a law of treatment. The same rule, by the way, applies also to replacement of torn and displaced integument and other soft parts. Facial deformity from trauma is often a discredit to the original surgical attendant. Much satisfaction will come to the family physician, who, though not a surgical specialist, has grit enough to administer the first-aid to a lacerated face in much the same way that his wife would act upon his torn coat. To put the torn edges at once in place, and keep them there with stitches, would be her motto. He should do the same with a torn face; but would better not use continuous sutures and should leave space for ooze of blood and drainage between some of the stitches. She would perhaps wash her hands before starting the job. He should clean both his hands and the patient's face ere he sew up a wound.

When there is a considerable loss of bone in a gunshot fracture or after excision of the lower jaw for malignant disease, the ends

of the fragments remaining should be held apart with a spreading dental apparatus to prevent dragging of the ends together by muscular action. The resulting contraction, if not thus averted, will become confirmed by muscular and cicatricial changes and a V-shaped jaw or other deformity produced, which may be curable never or only after months of painful treatment. If the ends are held apart by a temporary interosseous mass of modelling compound, a wire brace in the bone, an interdental splint or other fixation apparatus for a few weeks, the fragments will remain

FIG. 1.—Excision of mandible. Two inches removed with Masland electric saw. Rigid metal wire inserted in mandibular canal to hold fragments apart. Photograph taken several weeks after operation.

apart. Then a permanent prosthetic appliance may be adapted or an osteoplastic operation performed to complete the body of the mandible and restore facial contour.

Large flaps of skin and muscle may be swept from their bony attachments in machinery accidents and in military rivalry. The primary appearance of a patient whose face is so ripped apart is appalling. The bloody masses of integument, muscle and mucous membrane may be smeared with tears, saliva and dirt and contain fragments of bone, detached teeth, food and vomitus. Speech may be almost impossible from laceration or swelling of the oral

structures, and asphyxia impending. Thorough cleansing, sometimes with excision of damaged tissues, and an immediate replacement of the huge flaps, torn from scalp, forehead, cheeks or chin, will restore the patient's visage to a fair resemblance of a human face. It will also, in addition, add vastly to the chance of moderate septic symptoms and lessen deformity from scar distortion.

The availability of ordinary carpet tacks and small staples for keeping the replaced tissues in contact with the underlying bones will be recognized by surgeons with a mechanical turn of mind. Dental surgeons have shown that spring trusses somewhat like inguinal hernia trusses may be used for this purpose where sutures seem unserviceable. Use is made of the floor of the nose or an intermaxillary splint is inserted to give a supporting base for the spring; extensive flaps may thus be kept in normal relation to the uninjured structures. Wire or silkworm-gut sutures, inserted into the loosened integument, may be carried by means of long straight needles through the deep structures into the mouth; there they may be fastened to teeth of the upper jaw. A piece of wire twisted around the neck of a canine tooth or fastened to a hook soldered to a metal band, clamped on any available tooth, will give the oral end of the suture the desired hold. Any convenient tooth may be used as the anchor.

I have tacked, with much satisfaction, a plastic flap from back to cranium in accidental scalping of a child. In plastic operations on cleft palate, a valuable expedient in some forms of uranoplasty is to hold the bilateral mucoperiosteal flap against the denuded bones with a long mattress suture, the two ends of which are carried up through the palate cleft into the nose and out the anterior nares. Here the ends are tied together outside of the columella. One end may be made, with a needle, to perforate the quadrangular cartilage of the septum so that the two ends may be knotted together, just within the orifice of one naris. This intrapharyngonasal suture I have employed recently in several operations and believe it an improvement in technic.

Another recent detail in plastic closure of cleft palate was sug-

gested, I think, by Dr. J. R. Eastman. He draws the pillars of the fauces toward each other with a catgut suture after the urano-

FIG. 2.—Uranoplasty for congenital double cleft of soft palate. Horseshoe flaps displaced backward and anterior edge held against bony palate by intranasal suture. Faucial pillars were temporarily stitched together.

FIG. 3.—Appearance of mouth shown in Fig. 2 after union. Taken five weeks later. Union complete. Shadow at left is not to be mistaken for a fissure.

plasty is completed in order to take the strain off the stitches in the soft palate. This non-chromicized suture is absorbed in a few days when its support is no longer needed. It is valuable to prevent too great tension on the other sutures in the period of greatest danger, which is immediately after the recovery from anesthesia during a few days after that of operation.

Similar control of a tongue, when detached by gunshot or operation, may be obtained with a suture through its base knotted around the hyoid bone. After the tongue has lost its hold on the genial tubercles of the mandible, by reason of excision or avulsion of the median part of that bone, the danger of asphyxia from the tongue falling backward during sleep may be great unless thus averted.

Ptosis of the upper eyelid, whether due to traumatic paralysis or that from congenital defect in the nerve supply, I have relieved with considerable success by a muscle substitution operation when the fibers of the occipitofrontalis muscle have their normal innervation. The result has shown well in a child with bilateral congenital palpebral ptosis. In her instance, on one eye, I operated by the Wilder method, with only moderate success. Upon the other after failure of the Wilder method I used the one suggested by me. It consists in turning down a band of muscle from the frontalis and thrusting it through a tunnel beneath the skin of the brow so as to be fixed with sutures to the upper edge of the tarsal cartilage. This is accomplished by turning up a flap from the forehead by means of a vertical incision near the middle line and a curved cut within the eyebrow. Two strips of muscular fiber are attached at the bend in the overturned muscle; these are cut from the sides of the gap left in the frontalis by the transfer of the first band of fibers to the tarsal cartilage. The diagram and photographs show the method and the result.

Injurious tension on sutures employed to bring skin flaps together, across a wide gap, may be neatly lessened by sewing hooks on strips of adhesive plaster. One of these hook-strips stuck to the skin on each side of and parallel to the wound furnishes a ready means of lacing up the skin so as to take the

strain off the sutures. Subcutaneous absorbable sutures serve a similar purpose.

Lexer, of Berlin, published a few years ago the results of researches by himself and others in physiological and clinical investigations of plastic operations. In this country, Davis has contributed valuable ideas; among others, the use of rubber netting to hold skin grafts in place against the unhealed tissues

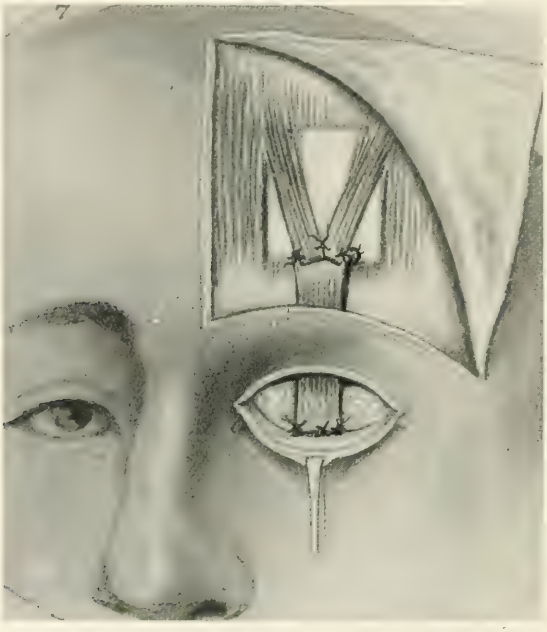

FIG. 4.—Diagram of Roberts's muscle substitution operation for ptosis of upper eyelid.

beneath. Esser, of the Austrian army, recommends what he calls epidermic inlay with dental modelling composition. This device keeps Thiersch grafts in accurate contact with the underlying surface by means of pressure from a negative of the surface, made of sterile dental compound. The method is available for skin grafting the raw surface of a skin flap to be used for repairing the mouth or cheek, to deepen the conjunctival sac for wearing a

glass eye, or to obtain an epidermic surface on both sides of a flap for any operation. In the last case, the surgeon freely undercuts the intended flap, makes a cast with heat-softened modeling composition, which soon hardens, of the cavity under the skin, covers the entire surface of the cast with thin skin

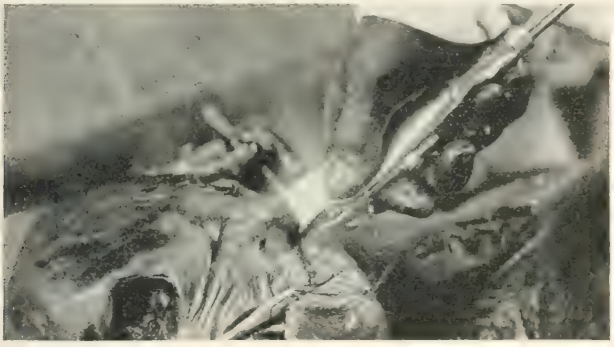

FIG. 5.—Excising mandible of cadaver with Masland electric saw.

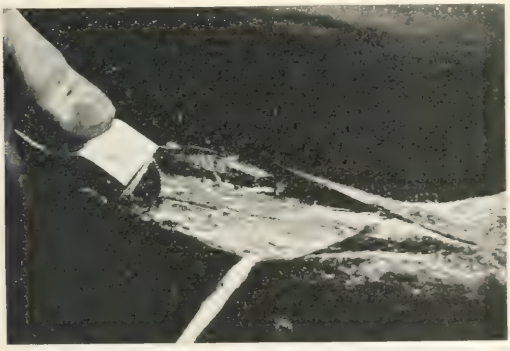

FIG. 6.—Sawing out tibial graft with Masland saw for bone grafting mandible.

shavings with their epidermis against the cast, pushes into the hole the cast covered with grafts, and sews up the wound. Two weeks later, he removes the buried cast from the cavity by an incision. These maneuvers furnish one or more flaps with normal skin on one side and Thiersch graft skin on the other. These are used for the next step of the intended operation.

One of the most satisfactory outcomes of the present interest in osteoplastic surgery, so far as my own work is concerned, has

FIG. 7.—Making osteoplastic cranial flap on cadaver with Masland saw (model 1918) and Roberts's trephine made in 1882 for trephining with Bonwill dental engine. This figure also shows bonegraft wired into mandible after employing Masland saw.

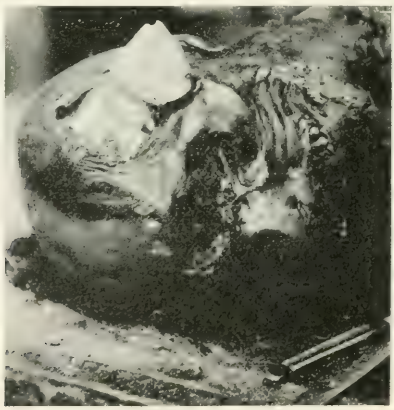

FIG. 8.—Osteoplastic flap so made everted.

been the development by Dr. H. C. Masland, of Philadelphia, in his osteoplastic saw, which I have been using in operating-room

and the surgical teaching laboratory. He has devised an instrument superior to any electric saw for all sorts of surgical work with which I am acquainted. It is convenient in size, and may be readily sterilized. It makes with accuracy and rapidity the osteoplastic trap-doors needed in brain surgery, the bone grafts from the tibia used in fractures and in tuberculosis of the vertebræ, and gives the surgeon an ever ready instrument for excision of mandible or rib. It is run by a motor and flexible cable, and is guided with one hand of the surgeon with almost the convenience and delicacy of a pocket knife. In craniectomy two small openings are made with an electric trephine or flat burr, devised by me long years ago, or with any form of perforator, to gain an entrance for the dural separator. The saw then cuts vertical or oblique incisions in the bone at the surgeon's will, and enables him to operate expeditiously and safely without danger to the patient, himself or the fingers of his assistants.

The usual accessory instruments, run similarly with an electric motor and cable, provide a rapid means of drilling bone for wiring fractures, making dowels, trimming pegs, and cutting slots for inlay-grafts and excising maxilla or mandible. The accompanying figures will give an idea of how Dr. Masland's saw has proved a convenience to me. I became acquainted with it a long time ago; but have only within a few weeks seen his improved model. This is far superior to his original tool, though that at once impressed me as having features not possessed by any other surgical saw for cranial operations then known to me.

Seeing during the past winter Masland's successive improvements in his osteoplastic saw has revived my interest in cranial perforation, an operation so important in general and plastic surgery. The *Philadelphia Medical Times* published on December 31, 1881, pp. 206–207, a short article by me detailing some experimental work on the cadaver with a flat face burr rotated with the Bonwill surgical engine. I used what was called by the dental instrument maker a fissure burr to trephine the skull and elevate a depressed fracture. With this burr I readily made "a circular cavity in the outer table of the cranium. This

was carefully deepened until the vitreous table was perforated." There was no disk to remove, because the burr threw out all the bone-dust; thus it enabled me, by withdrawing the burr from time to time, to observe the character and depth of the perforation being made. A circular hold about one-quarter of an inch in diameter was quickly cut through the brain case, exposing the dura mater without injury to it or the enclosed cerebrum. A steel elevator was inserted into the hole and used to prize up the depressed fragment driven upon the brain by the crushing blow previously given.

FIG. 9.—Roberts's cranial trephine made in 1882 for use with Bonwill dental engine. The hole in the side is to enable the operator to push out the button of bone and clean the trephine.

FIG. 10.—Roberts's cranial trephine for use with electric motor.

My deduction was that such a burr would readily grind away osseous tissue, but, though rapidly rotating, would not be likely to injure by abrasion the surface of a soft structure like the dura mater. I could run it against my soft finger tip without injuring the skin. The convenience of the method was seen to be enhanced also by the ease with which sharp and irregular fracture edges could be cut smooth with the burr used to make the opening in the cranium.

I quote a portion of the article from the *Times* of 1881:

"The method of trephining the skull with the surgical engine of Bonwill, which I believe to be the only one sufficiently powerful, would then be as follows. Pick out a burr one-fourth or three-eighths of an inch in diameter, well tempered and having a flat face deeply cut; then fixing it in the mandrel, close up to the hand-piece, have the engine-crank turned with great rapidity. When the skin and periosteum have been dissected up, apply the burr to the sound bone nearest the most depressed portion of the fracture, and at first tilt the burr a little on the edge until a shallow groove has been made on one side of the proposed perforation. This prevents the burr slipping from the smooth convex cranium. Keep the burr constantly moistened by means of a wet sponge held over it and occasionally squeezed. When the perforation has been made, use the elevator as in ordinary trephining. If there is difficulty in elevating or removing the fragments, cut away with the burr the edges which cause locking. Hey's saw or bone-cutting forceps will not be required.

"The ordinary burr furnished by makers of the engine is sufficient, but the face could with advantage, I think, be cut deeper. Instead of the ordinary burr the central portion of the face might be bored out, leaving then a burr that would remove a disk such as the ordinary trephine does, and which might also be made conical. These changes, however, would be of doubtful advantage, though I shall probably experiment with this form of burr.

"The use of the surgical engine for perforating the cranium is, as far as I know, novel, but it is very possible that others may have experimented on the cadaver or living subject and found similar results."

Later I had a small trephine without a center pin made by the dental instrument maker, but never used it on a patient. I found that the surgical engine, as then constructed, was not convenient for general surgical work. It required too much adjustment to be immediately ready for emergency surgical operations. At that distant time, electric lights and electric motors were not at hand as they are now, and the surgical engine with cable was a poor

thing compared with that in use today. I have not yet found my old flat burr, but here is the little trephine made in the winter of 1881–82, still sharp, still unrusted. It was brought into active service a few days ago, when Dr. Masland and I wished to use it in connection with his efficient saw. It bored with youthful energy the two holes in the parietal region, needed for the introduction of his dural separator, prior to his accurate construction of an osteoplastic trapdoor for exposing the middle meningeal artery. It proved pretty conclusively that it would be as safe, rapid, efficient and satisfactory for perforating the cranium as is a sharp scalpel for opening the abdomen. It seems to me to make the flat or fissure burr unnecessary, though that could be readily used instead of the trephine.

The advantages of the electrically driven burr or trephine over some of the more recent instruments for penetrating the skull are its simplicity and inexpensiveness. It needs merely to be attached to the mandrel of any surgical engine run by hand, foot or electric power used for drilling bone. The Gigli wire saw, the Masland saw or any other means of making bone flaps or grafts, which requires a preliminary hole of entrance, is available after the trephine opening is made with my burr or trephine. It is probable that many surgeons now use electricially driven trephines. I mention my early experiments because such attempts have historical interest. When I devised an aseptic hand trephine, which was used a good deal some years ago, and had constructed the segment trephine for making large openings in the cranium, the initial steps were being taken by Keen, Birggs, Bergmann, Cushing and others which have borne such wonderful fruit in the domain of cerebral surgery.

When President William T. Briggs appointed me to open a discussion on brain surgery before this Association in 1885, I introduced in the title of my paper the word "Limitation." Notwithstanding that qualification, I was considered a foolhardy youngster who weighed not his words. Now, my juniors are teaching us how few are the limitations in operative surgery of the human brain.

DISCUSSION

Dr. Leonard Freeman, Denver, Colorado:

I want to call attention for a moment to a method of obtaining a flap for covering the defects in tissue about the chin and neck, especially in burns. Everyone is familiar with the raised red scars that contract and produce such terrible deformity about the neck and chin, everting the lower lip and exposing the teeth, so that the saliva runs out on the neck. The chin may even be pulled down on the breastbone in certain instances. The first step in the cure of such disfigurements is to remove every bit of scar tissue. It is often only the front of the neck and chin that is scarred by the burn, so that the upper portion of the sternum is left free. I have been able to obtain a "bridle flap" having its pedicles below the ears on each side of the neck, the main portion of the flap being obtained from the uninjured portion of the skin on the upper portion of the sternum. Such a flap can be loosened up entirely and brought up over the front of the chin. It gives a perfect flap of skin to cover the chin and neck in front, without scars and without contracting tissue. I can assure you that the procedure gives a very excellent and satisfactory result.

Dr. Archibald MacLaren, St. Paul:

When I saw Dr. Roberts's name on the program I was interested along exactly the line of Dr. Freeman's discussion, because the only thing I could find in looking up the literature of burns under the chin was a case reported by Dr. Roberts in one of the recent books on surgery; he did not, however, tell exactly how he obtained his flap. Therefore, in studying the technic in an old English surgery I found a description very similar to that of Dr. Freeman, except that the flaps were made by loosening the skin from the shoulder, where they were left attached at both ends for two weeks or more, it being a two-stage operation. They were made long enough so that they could overlap, because when you take the scar out from underneath the skin you are amazed to find a four-inch gap instead of one-and-a-half-inch scar. Therefore, the flap must be made double width. Dr. Roberts's description of a similar case was that he got his flaps from the back of the neck. This makes a long flap, but it smooths down very quickly and gives an astonishingly satisfactory result.

Dr. Thomas W. Huntington, San Francisco:

I take this opportunity to call attention to a very ingenious bit of work seen in Northern Italy. I was asked to witness the final opera-

tion in a case that had been under observation for six or eight weeks. When I saw the patient on the operating table his lower lip appeared to extend from the angle of the mouth to the ear, and it was amply provided with mucous membrane. The surgeon in charge, an Italian, told me that he had received a shrapnel wound, tearing the side of the cheek from the ear to the angle of the mouth, with the loss of one-half of the superior maxilla, leaving attached to the tissues at the lower portion of the wound a large flap of mucous membrane. Having had large experience in wounds of that type, he recognized the importance of maintaining the viability of this mucous membrane curtain and made that his chief issue. After cleansing the wound as well as possible, he brought the flap of mucous membrane over, attaching it to the skin margin, as in lower lip cancer. When I saw him the mouth was perfectly clear and clean, the wound in the upper jaw was healed and all that was left to be done was to lift this mucous membrane lip flap from its attachment, making a free dissection, repairing the mucous membrane of the palate to meet it and then, having ample room to work, he finally sewed the mucous membrane of the artificial lower lip to the median line and closed the wound. The transformation was truly remarkable. The surgeon said he had never done just such an operation before but some similar ones, and he expected a good result, giving the patient complete mobility of the lower jaw, so that with the teeth on the opposite side he will be able to get along comfortably.

THE USE OF THE PEDUNCULATED FLAP IN RECONSTRUCTIVE SURGERY

By JOHN STAIGE DAVIS, M.D., F.A.C.S.
BALTIMORE, MD.

In this war there have been many whose wounds have caused the loss of skin and subcutaneous tissue, and even deeper tissues, in situations which ultimately will require a resistant elastic healing before a satisfactory functional result can be obtained. Many of these defects can be properly remedied only by the use of pedunculated flaps of skin and subcutaneous tissue. Some of us will see these cases abroad and others will be called upon to treat them if they are sent home. For this reason it seemed worth while at this time to consider this subject with which, perhaps, you are all more or less familiar.

A brief review of the development of the use of pedunculated flaps may be of interest.

The history of pedunculated flaps is closely associated with the development of rhinoplastic operations, and nearly all of the procedures used were originally employed in the process of this development. Long years before plastic surgery was attempted in Europe, certain individuals of the tilemakers' caste in India obtained wonderful results in plastic operations with pedunculated flaps from the cheek and later from the forehead in the repair of amputated noses. This is known as the Indian method.

It is interesting to note that plastic surgery was practised in India and Egypt, as has been shown by the sacred writings of India and in Ebers' papyrus, in both of which rhinoplasty is mentioned as a well-known procedure.

Celsus speaks of the restoration of ears, noses and lips by the aid of the neighboring skin, and Galen, Antyllus and Paul of Aegina also mention these operations. Then for many years the art of plastic surgery seems to have been lost, at any rate to European surgeons.

In the middle of the fifteenth century, about 1442, Branca, or Brancas, a Sicilian surgeon, was able to build noses by pedunculated flaps from the skin of the face, and following him his son Antonius is said to have restored a lost nose by means of a flap from the arm. The first report of the use of the arm flap in medical literature is a brief note which is found in a work on anatomy by Alexander Benedictus, published in Venice in 1497.

Other surgeons of more or less repute were impressed with this work, and various allusions to the operation are to be found in surgical writings of the sixteenth century.

The work of Gasper Tagliacozzi (1546–1599), published in 1597, was the first systematic treatise on plastic surgery. In it he described several operations, but gave special prominence to his method of rhinoplasty, in which he used a pedunculated flap from the arm.

Two parallel incisions, 20 cm. long and 10 cm. apart, were made down to the fascia on the anterior aspect of the left arm. The flap was separated from the fascia and was kept away from its bed by oiled linen, but the pedicles at each end were not divided.

After a fortnight, when granulation and thickening had occurred, the upper pedicle was cut and the flap was sutured into the defect after revivification of the edges. The arm was held in position by a special harness, and after three weeks the other pedicle was amputated from the arm and the flap was shaped and fitted into the desired position. This is called the Tagliacotian or Italian method.

The pupils of Tagliacozzi continued to carry out his method, but within a few years the method was lost sight of, and in course of time began to be considered impossible.

Reneaulme de la Garanne, in 1712, tried to rehabilitate the method, and proposed sewing into the defect the fresh flap

immediately after raising it, without waiting for it to granulate. However, the art remained lost to practical surgery until 1816, when von Graefe again revived the method and reported one successful case. He modified the method by cutting the upper pedicle at once, and by sewing the fresh flap into its place without waiting for it to granulate, thus making of it a single operation.

J. C. Carpue, of London, was the first surgeon who successfully performed rhinoplasty by the Indian method and reported two successful cases in 1814 and 1815. Since that time the operation has been performed many times and numerous modifications have been made in the original method.

The use of the pedunculated flap of skin and subcutaneous fat, based either on the Indian or the Italian method, and applied fresh or granulating, gradually became more common, especially for the relief of contractures and in locations exposed to pressure and friction.

The transplantation of pedunculated flaps by successive migration was probably first employed by Ph. J. Roux in supplying lost portions of the cheeks: the flap was first taken from the thigh of the patient (Pancoast).

Blandin reported a case in which a part of the upper lip and a part of the cheek and alæ of the nose had been destroyed. He raised a flap from the lower lip and attached it to the upper lip, then transferred it successfully to the cheek and nose.

The first report of the use of a pedunculated flap from adjacent tissue by an American surgeon is that of J. Mason Warren, of Boston, in 1837. He was successful in constructing a nose by the Indian method with a pedunculated flap from the forehead. T. D. Mütter, of Philadelphia, in 1842, reported 3 cases in which he successfully shifted large pedunculated flaps of skin and subcutaneous fat from the shoulder and deltoid region, to fill defects left by relieving contractures of the neck and chin following burns.

Joseph Pancoast, of Philadelphia, in 1842, reported the successful use of pedunculated flaps from the cheeks, forehead and upper lip.

Frank H. Hamilton, on January 21, 1854, in the Buffalo

General Hospital, raised a pedunculated flap of skin and subcutaneous fat, 4 x 7 inches, from the calf of a man's leg for the relief of a large traumatic ulcer of the other leg. This flap was held away from its bed by dressings, and remained viable, although there was considerable shrinkage. After two weeks he freshened the under surface and edges of the flap, excised the ulcer and part of the cicatrix, then partly covered the wound with the flap and secured the legs together. Two weeks later the flap was amputated from its base and a portion of it subsequently sloughed.

After this there were reports on the subject from the United States, England, France and Germany, but it was not until the work of Maas, in 1884–1886, that widespread attention was given to the use of pedunculated flaps.

His papers were so convincing that new impetus was given to the method. Since his death there has been much work done on the subject by many surgeons, and splendid results have been reported.

The original Indian and Italian methods have been modified from time to time, but the basic principles of these methods are unchanged.

By a pedunculated flap I mean a mass of tissue, usually the skin and subcutaneous fat, which is raised from its bed but is left attached to the surrounding skin at a selected portion of its margin. There is another type of pedunculated flap with a pedicle of subcutaneous tissue, the skin being cut all around it. It was first used by Gersuny, and is useful in closing defects in the mucous membrane. Esser has recently described similar flaps, calling them "island flaps."

Through this skin or subcutaneous attachment, called the pedicle, the flap receives its blood supply. The flap can be shifted as far as its pedicle will permit, to fill the defect.

Pedunculated flaps may be obtained from tissue in the neighborhood of the defect or from a distant part. There may be a single, or a double pedicle.

There are three general methods of obtaining pedunculated flaps:

1. The Indian method, in which the flap is obtained from the immediate neighborhood of the defect and is shifted into its new position by more or less twisting of the pedicle. The pedicle of the flap may be adjacent to the defect or it may be necessary for the pedicle to bridge over normal tissue before the flap can be placed in its new position.

2. The Italian or Tagliacotian method, in which the flap is obtained from a distant part, usually from the arm.

3. The French method of sliding flaps from adjacent tissue, in which process there is little or no torsion of the pedicle.

A way of further utilizing pedunculated flaps was described by Dr. W. S. Halsted, in 1896. He reported a method which he had used in the treatment of an extensive burn of the cheek, neck and arms, and he spoke of the method as "waltzing" the flap. He says: "None of the original attachments of the last flap which we used have been preserved. The flap has twice been twisted upon itself, first upon a small pedicle of skin, original tissue we may call it, and secondly, upon a little broader pedicle of cultivated cicatricial tissue. The flap has probably made a complete revolution." In my own work I have found this a most useful method, and by this means it is possible to gradually shift masses of skin and subcutaneous fat into positions far removed beyond the restriction of the original pedicle.

The transfer of the flap may be single, that is, when it is placed directly on the defect. This may be done whether the flap is from the neighborhood or from a distant part, and either immediately after cutting (fresh) or after granulations have formed.

The transfer may be multiple or by *successive migration*, that is, where it is impossible on account of its position to place the flap directly on the defect. For instance, in cases in which it is advisable to use a flap from the abdominal wall to repair a chin the flap is raised and grown into an incision in the forearm or hand. Then, after the circulation is established from the forearm, the pedicle is amputated from the abdomen and the flap is transferred on the forearm to the chin. In due time the flap is cut away from the forearm and is immediately fitted into its new bed.

This method has also been used from abdomen to chest, to neck, to chin and in other combinations. In this process of gradual transfer the raw surface of the flap necessarily granulates, and the shrinkage is considerable.

If an abdominal flap be used with a pedicle on one side of the midline it is advisable, on account of arterial distribution, that the skin of the flap should be taken from the same side. This is unnecessary when the pedicle includes the skin on both sides of the midline.

The area from which the pedunculated flap is taken may be closed by suture if the skin is lax, or after undercutting and sliding. If closure is not possible on account of the size of the area, then it may be covered with skin-grafts, preferably of the Thiersch variety.

Pedunculated flaps may be simple where only the skin and subcutaneous tissue are used, or compound where periosteum, bone or cartilage is included in the flap.

In compound flaps the periosteum or bone may be taken up with the flap without being separated from the soft parts, as when periosteum and bone are raised from the frontal bone in certain rhinoplastic operations, or when a portion of the clavicle is raised with a flap from the neck to repair a jaw defect.

When cartilage is used a shaped section of cartilaginous rib is ordinarily transplanted to the desired location in the future flap, and after it has become established in its new position from three to six weeks the flap containing the cartilage is raised and shifted to the defect. This method is also used when it is desirable to use free bone or free periosteum in a flap.

Double-faced Flaps. If a pedunculated flap of any considerable size is used to construct a lip or eyelid, or to fill a defect inside the mouth, an epithelial and not a raw surface should be placed inside the cavity. Unless this is done contracture will take place, as the mucous membrane does not spread with sufficient rapidity to cover the raw surface in time to prevent contracture.

In some instances, for example, where the reconstruction of the lower lip is contemplated, it is necessary to have a flap which is

covered with epithelium on both sides. This may be accomplished by grafting the under surface of the flap and waiting until the healing is complete before transferring the flap, as is well described by Watts. Another method which I prefer is folding the end of the flap on itself and allowing the raw surfaces to heal together. Then transfer in the usual way. If a supporting substance is necessary in such a flap, free cartilage may be inserted between the raw surfaces.

Lefevre says that Chavannaz had good results in two cases by turning the raw surface of a pedunculated flap inside in cheek plastics. Lefevre did some experimental work on dogs to prove the point, and says that the results were very satisfactory and that the raw surface healed in from sixteen to thirty days.

My own experience leads me to believe that only flaps covered with epithelium will prevent subsequent contractures when turned inside the mouth.

The attachment of one person to a pedunculated flap raised from another, which may be called symbiotic transplantation, has been attempted a number of times, but without very satisfactory results. Finney reported an unsuccessful case of this kind before this Association on June 5, 1909, and quoted Lund, who had had little better success in his own case. In both of these cases there were unavoidable complications which tended to cause failure. The method is even more trying on the participants than when autoplasty is practised by pedunculated flaps from distant parts, and for this reason is not to be recommended. However, there is no reason why such a procedure should not be successful under favorable conditions.

O. Laurent reported four cases in which he successfully used pedunculated flaps from other persons for the repair of extensive humerus or femur defects. The donors and recipients were fastened together from eight to ten days. Excess bone in amputation stumps, which required shortening, was used in each case and the results were said to be satisfactory.

In using pedunculated flaps the following are some points which experience has shown to be essential for success:

The patient should be in the best possible physical condition. Asepsis rather than antisepsis should be maintained throughout the operation and during convalescence. The tissues should be treated with the greatest consideration. Keen cutting instruments must be used to avoid unnecessary injury to the tissues. The flaps should be handled with special forceps or small sharp hooks. All hemorrhage should be checked in the area into which the flap is to be transferred. Accurate apposition of the sutured edges is desirable, as prompt healing minimizes scar tissue.

The sutures should be placed so as to avoid tension, which always jeopardizes the success of the flap.

Pedunculated flaps are specially valuable when a pad of fat is required to fill a defect in addition to the whole thickness of the skin.

Flaps usually include the skin and as much of the subcutaneous fat as is needed. The fat should be somewhat thicker than is actually necessary to fill the defect, as the excess is taken care of by subsequent shrinkage.

The shape of the flap must correspond fairly accurately to the defect which it is to cover. Long pointed flaps should be avoided on account of almost certain necrosis of the tip. Thin flaps are so pliable that they can be easily adjusted to fit a defect of almost any shape, but especially in rhinoplastic operations it is desirable to outline the flap from a carefully calculated pattern.

The skin of pedunculated flaps must be chosen with some regard to the character of the skin surrounding the area into which it is to be placed. That from the immediate neighborhood usually matches better than that from distant parts.

A flap of hairy skin should never be turned into the mouth or any other mucous lined cavity, as the hair will continue to grow and will give much discomfort. This has also been the rule about shifting flaps of hairy scalp to fill defects on hairless portions of the face. Recently, P. P. Cole reported that he used hairy scalp to repair a face defect and that subsequently by radiation the hair was readily removed, leaving a smooth skin.

The flap should be cut about one-third larger than the area it is

to fill, as there is always immediate shrinkage which is in the direction of the elastic fibers.

Normal skin is necessary for a successful flap, as any scar on the edge of a flap will usually slough, and a scar running across a flap will completely cut off the circulation beyond it.

If possible always excise all scar tissue, especially along the edges to be sutured, as the healing will be more satisfactory if normal tissues are approximated.

The pedicle should be as broad as possible, but in all flaps which are to be twisted it should be narrower than the body of the flap. In flaps from the immediate neighborhood always aim to have the pedicle very close to the loss of substance, and when practicable the long axis of the pedicle should be in the same direction as the axis of the flap in its new direction. The pedicle of a flap should be in the same line as the area to be filled.

The elasticity of the skin will allow a curved flap to assume a straight position without difficulty.

As a general rule the flap should never be longer than two and a half to three times the width of the pedicle, unless it contains a main artery, in which case the pedicle may be much less wide and the flap less thick. However a main artery is not essential if the pedicle is adequate and the flap is thick and includes small vessels for its proper nutrition.

If the pedicle of a flap adjacent to the defect is too short to allow turning into the defect without tension, the incision not terminating in the defect should be prolonged outward.

A pedicle should never be notched at the time of implantation to make it fit better, as the circulation might be impaired. If there is puckering of the edges of a pedicle it can be adjusted after the new circulation is assured.

Twisting or too much tension on a pedicle may cause shutting off of circulation and gangrene of the flap.

There is sometimes gangrene of a flap which has an excellent blood supply due to lack of drainage from the flap. In other words the flap is choked by blood and lymph entering it and being unable to get out promptly. This is especially to be feared

if the pedicle contains a main artery. To overcome this danger C. H. Mayo suggested superficial scarification of the flap to allow surface drainage until proper vessel drainage is established, and I have found the results satisfactory. When a long narrow flap is required and there is doubt about the blood supply it is advisable to raise it from its bed, but to leave it attached at each end after the method advised by Croft, although this is what Tagliacozzi did in his original operation. If this is done close the skin beneath the flap if possible or keep it separated from its bed by rubber tissue or graft the bed beneath the flap with Ollier-Thiersch grafts. After two or three weeks cut one pedicle, then freshen the granulating surface and transfer the flap in the usual manner, subsequently severing the other pedicle.

I usually wait from ten days to two weeks before amputating the pedicle of a flap. Some have advised amputation as early as the fourth day while others insist that three weeks should elapse before severing the pedicle. The circulation of the flap may be tested before cutting the pedicle by applying a stomach clamp across the pedicle tight enough to shut off the circulation, but not sufficiently tight to damage the tissue. The amputation may be done by notching one or both sides of the pedicle, thus gradually cutting off the circulation, or it may be done at one time. After the pedicle is cut through, the end of the flap toward the pedicle should be fitted to its proper place at once and, if possible, the stump of the pedicle should be returned to its original bed, as in this way a better result can be obtained with little, if any, loss of tissue.

Flaps of normal tissue are often successfuly shifted into the midst of scar tissue, as in the popliteal and cubital spaces, but the circulation of these flaps should be especially good.

Immobilization of the part with plaster of Paris, crinolin or splint is essential, and the dressing next to the transplanted area should be soft and very carefully and evenly applied. My own preference is for the use of compresses wet with normal salt solution for the first forty-eight hours. In shifting double pedicled flaps on the neck or from the neck to the chin or lip it is advisable

to provide for drainage with a small protective wick in each lower angle.

The use of strong antiseptics should be avoided. I prefer horsehair for skin sutures and use a half-curved corneal needle, which penetrates the skin easily. Catgut is advisable for buried sutures and ligatures in plastic surgery.

The flap should be inspected frequently, as the evacuation of a collection of serum, the combating of a slight infection, or the loosening of tight stitches may change into a success what might otherwise be a failure.

Occasionally it may be necessary within the first forty-eight hours to shift the flap back to its original position, when for one reason or another its death seems imminent.

Skin flaps may be turned into the mouth to take the place of destroyed mucous membrane. Flaps may also be inserted by tunnelling under normal tissue. This may be done with the ordinary pedunculated skin flaps or with island flaps.

Double pedicled "gauntlet" flaps raised from the chest, abdominal wall, back or thigh are often used for the repair of lesions involving the hand or fingers. The flap is raised and the part is slipped beneath it and is immobilized. After the blood supply is assured the pedicles are cut, either both at one time or separately, and the edges of the flap are sutured into position.

The transplantation of flaps whose pedicle consists only of the temporal artery, veins, etc., was reported by Monks in 1898. He constructed a new under lid by using a crescentic-shaped flap of the skin of the forehead, into which the anterior temporal artery ran. He then dissected out the artery and accompanying veins, and after tunnelling passed the flap through and sutured it in position, thus leaving the vessel under the skin. Horsley, in 1915, suggested a similar procedure for repairing a cheek defect, not being aware of Monks' report. He did not use the tunnel method but implanted his vessels in an incision which was closed over them. The principle was the same, although the size of the flap and the technic were different.

If by chance the nerve which supplies the portion of the skin

which is used as a flap should pass through the pedicle, the sensation remains in the flap until the pedicle is cut. After that the sensation is cut off for the time being. After five or six weeks sensation begins to return by the nerve supply coming in from the periphery, as in whole-thickness skin-grafts. The flap regains tactile sensibility first, then pain, and finally temperature sense. If the flap is large the central portion may not regain its sensation for a considerable time.

In my last two rhinoplastic operations by the Indian method the pedicle contained the left angular artery and evidently an undisturbed nerve supply, as when the stitches were removed along the alæ and columna, both patients complained of pain high up on the forehead. This sensation was frequently tested and continued for several weeks until the pedicle was cut, after which all sensation was temporarily eliminated.

Grafts of all types may become pigmented, but pigmentation seldom occurs in pedunculated flaps, and for this reason they are for cosmetic reasons to be preferred on the face and other exposed positions.

In addition to the use of the ordinary skin and subcutaneous fat flap, pedunculated flaps of other tissues may be used in reconstructive surgery.

Mucous Membrane. Pedunculated flaps of mucous membrane may be used with satisfaction when available for filling in lip and cheek defects.

Fat. Pedunculated flaps of fat are often used to fill defects in bone, to raise depressed scar, to surround tendons and nerves and to prevent adhesions. They are also used in joints, but the combined fat and fascia flap is superior in arthroplastic operations.

Muscle. Pedunculated flaps of muscle are used to fill defects in bone, as after mastoid operations, and to fill out depressions, as, for example, those caused by the destruction of the malar bone in war wounds.

Fascia. Pedunculated flaps of fascia are often used with success to reinforce weakened tissue, as, for instance in hernia operations.

A review of the literature shows that during the last one hundred years practically every portion of the surface of the body has been repaired by means of pedunculated flaps for the relief of defects, either congenital or acquired.

The pedunculated flap of skin with the required amount of fat is one of the most dependable methods at our command for the repair of tissue defects. It is especially useful in repairing defects opening into the mouth or nose, bladder or vagina. No other surgical procedure is so effective in accomplishing permanent elastic healing in areas exposed to constant trauma as around joints, on the soles of the feet, etc.

A pedunculated flap with good circulation will live and succeed in positions in which free transplants are contra-indicated. The neglect of this valuable surgical measure is quite general among surgeons, but its many advantages should assure its constant employment in suitable cases.

By the use of pedunculated flaps function may be restored and cosmetic results be obtained in many cases otherwise beyond the help of surgical procedures.

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THE REPAIR OF LARGE GAPS IN PERIPHERAL NERVES BY NEUROPLASTY

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WHILE a great volume of scientific work has been done in the field of neurological surgery, especially in the realm of the brain and spinal cord, relatively little has been done in the surgery of the peripheral nerves. This branch, however, looms very largely in the great war that is now raging in Europe, in which countless thousands of injuries of the kind are taking place.

A wealth of experience in this, as in all branches of surgery, will doubtless bring about adjustment of many unsettled problems and throw a flood of light on such highly specialized branches as those of the nervous system. Observations of the reports made by many commentators in this field of surgery since the war began and during its progress convinces one that up to the present time the main work has been to assemble the material and the practical experience. At a later period, after the strife is over, the material will be sifted and delivered to the world literature.

It is observed that on the field and in the hospital, surgeons seem to adhere to more or less stereotyped methods of treatment in vogue in the past. There is even a disposition on the part of surgeons in high places to discard methods of treatment that have been proved to be successful. Thus the transplant, whether the auto, the homo, or the hetero variety, is decried as useless and the method advocated in this study for selected cases is given no place at all. Experience even in a very limited degree, which is the lot of most general surgeons who, after all, must deal with a

great many of these cases, must be evaluated with the experience of any other group.

The object of this study is to present 3 cases which embody certain variant principles of treatment and in which very satisfactory results have been attained. In point of fact, under no other method of treatment known to the writer, could relief have been attained, and for that reason they possess a certain intrinsic value. The 3 cases submitted illustrate the utilization of nerve flaps of both central and peripheral origin in order to bridge unusually large gaps in peripheral nerves.

The first case is the outline of one presented to the American Surgical Association in Philadelphia in June, 1909, the man having been brought to the scene of the meeting and exhibited.

G. E. C. developed in 1888 molluscum fibrosum, the tumors varying in size from a millet-seed to a walnut, disseminated over the trunk, head and extremities. In 1898 one of the tumors developed rapid growth in the right arm above the inner condyle of the humerus. After its removal local paralysis in the hand succeeded which passed away within six months. In May, 1907, a slight swelling was observed on the posterior midregion of the right thigh, which was painful and sensitive. After a direct injury sustained in December the tumor developed rapid growth. The slightest pressure over the tumor would cause the most intense local pain, which was transmitted down the leg and diffused over the foot. The pain finally becoming unbearable, he was admitted to my service in St. Vincent's Hospital.

Examination revealed a tumor as large as a goose egg in the central part of the right thigh over the sciatic nerve. There was a paretic condition of the muscles of the leg and foot on the affected side and scattered areas of hyperesthesia and anesthesia. The diagnosis made at the time was metastatic tumor of the sciatic nerve.

The first operation was performed February 4, 1908. A median incision was made over the tumor from its upper to its lower limits. The tumor thus presented proved to be the sciatic nerve, with abnormal contents. The surgical procedure had now to be

quickly determined. Because of the rapid growth of the tumor, its tendency to infiltrate surrounding parts, the loss of outline of nerve structure and the intense suffering a complete resection of the sciatic nerve was decided upon. The upper section of the nerve was made at the lower border of the gluteus maximus and the lower about one inch below the apex of the popliteal space. Hemorrhage was moderate. The anatomical parts were restored as carefully as possible. The wound was closed in layers with iodized catgut, and it was found on the tenth day that union had taken place by first intention. The segment removed was ten and three-quarter inches in length and the diameter of its greatest part was about three inches (Fig. 1).

An exhaustive report of the pathology of the tumor was made by Dr. J. C. Bloodgood, of Baltimore, and was pronounced to be malignant, a spindle-celled sarcoma which originated in the perineurial connective tissue.

Examination of the leg showed that there was absolute paralysis of the entire musculature of the limb and that sensation was abolished except over the area of distribution of the anterior crural nerve. Nothing could have been worse than the appearance of the leg. It was of a dark purple color, greatly swollen and edematous. Large blebs presented themselves over the entire involved area. The toes presented the appearance of threatened gangrene, and the loss of the leg seemed imminent.

Realizing that the leg in its existing condition was useless and a menace it was determined as the one feasible course to bridge the gap in the sciatic by making a flap from the internal popliteal nerve on the theory that thereby a path for the conduction of motor and sensory impulses could be established and, at the same time, provide a path for regeneration and avert the catastrophe of amputation. Accordingly on February 21, 1908, with the aid of student assistants in my surgical clinic, an incision thirty inches in length was made from a point midway between the tuberosity of the ischium and the great trochanter, extending to a point behind the internal malleolus.

The central end of the sciatic was found retracted above the

lower border of the gluteus maximus. The free ends of both popliteal nerves were next exposed and, as part of this operation,

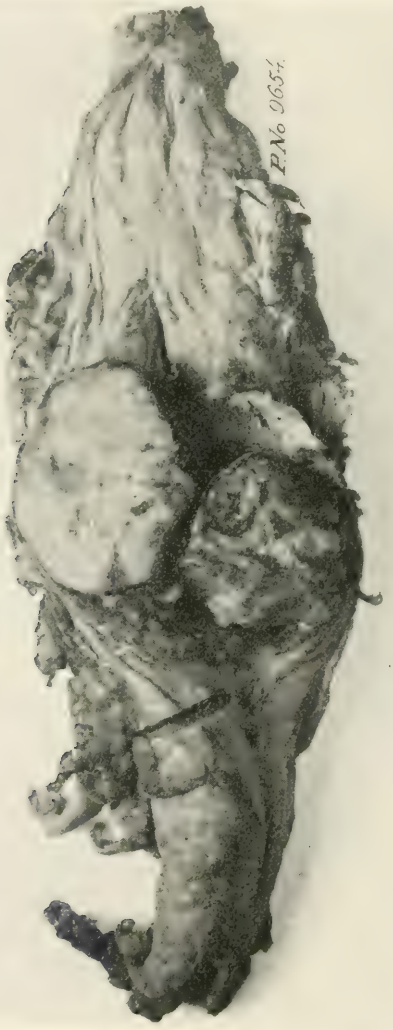

FIG. 1.—Segment ten and three-quarter inches in length removed from sciatic nerve. (Case 1.)

the end of the external branch was implanted and sutured into a cleft made on the lateral aspect of the internal popliteal half

an inch from its end. The internal popliteal nerve, which was still enlarged, was then traced by careful dissection to the inner side of the ankle and, beginning at the level of the lower border of the internal malleolus, a flap was lifted and split in an upward direction, care being taken at every step to avoid the division of any lateral branches. The division and lifting of this flap was continued upward to within half an inch of the divided end of the internal popliteal nerve. This flap was sixteen and three-quarter inches in length and its diameter a shade less than half the diameter of the nerve. Its end was implanted in a split made in the stump of the sciatic nerve and held by two very slender chromic stitches. The filament was not more than a line and half in diameter and contained four or five nerve fibers. It was handled with the utmost tenderness and buried from end to end by suture overlapping the underlying muscle, the motive being to avoid its destruction by scar formation and to permit the neurotization of the muscles of the leg. The wound was then sutured in layers and the entire length of the cutaneous incision closed by a subcuticular iodized catgut suture. The leg was invested in a plaster cast adjusted to the leg and thigh at an angle of 140 degrees. The first dressing, made on the tenth day, found the wound united throughout by first intention.

Examination of the leg revealed but one change, and it was very striking, the evidences of trophic disturbances were largely swept away and the leg presented a much improved appearance.

Believing now that if the transplantation of a few fibers split from one popliteal would do good by establishing conductivity and promoting regeneration, that a few more fibers might augment the benefits, a third operation was performed on April 7, 1908, sixty-seven days after the first operation and forty-six days after the second. In the intervals the limb was treated daily by massage and electricity.

The third operation consisted of an attempt to split the external popliteal nerve and utilize a flap in the same manner. This was a more difficult procedure, but a flap of the same length was finally lifted up and tucked in a separate muscular bed on the outer side

of the other branch, its end implanted into a cleft previously cut in the stump of the sciatic nerve. It was noted in this dissection that little or no scar tissue had formed in the line of the first transplantation. The wound was closed in the same manner and

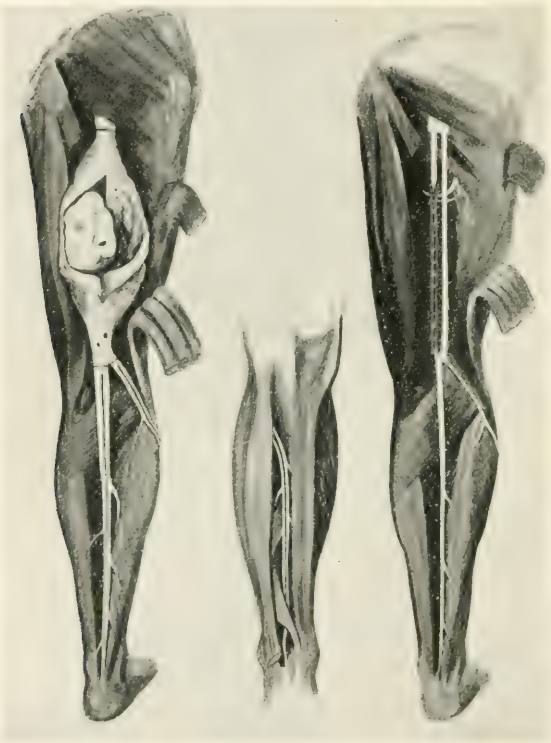

FIG. 2.—Showing the position of the tumor, the part resected, method of splitting the internal and external popliteal nerves, method of bridging the gap, the scheme of suturing peripheral flaps in muscular bed. (Case 1.)

united by first intention. A few weeks later the case was removed and an adjustable splint applied which permitted the leg very gradually to be extended to a straight line. Thereafter treatment by massage and electricity was instituted and continued up to the time of his discharge (Fig. 2).

Examination within two weeks revealed marked improvement in the nutrition of the leg and all trophic disturbances seemed to have cleared away except over the central part of the anesthetic zone, where the skin appeared glazed and patches of epithelial scales were in evidence. When walking was permitted after the removal of the cast there was no pain or discomfort. After the lapse of three or four months the leg could be moderately flexed upon the thigh, but the condition of foot-drop was absolute. Progressive improvement hereafter took place in the motions of the leg, so that it could be more readily flexed and extended.

Observations made within six months after the last operation revealed partial reaction of degeneration of the hamstring muscles and the flexors of the leg and complete reaction of degeneration of the flexors of the foot. Observations made one year after the last operation revealed electrical and motor recovery of the hamstrings and the flexors of the leg, partial reaction of degeneration of the extensors of the foot and complete reaction of degeneration of the flexors of the foot. Seven years later this man appeared at a meeting of the American Medical Association in San Francisco, in 1915, in a discussion of a paper on nerve regeneration by Dr. Dean Lewis. He is still living, and whereas after a lapse of ten years there has been no recurrence of the disease, there has been continued recovery of function (Fig. 3).

Analysis of the effect of the injury: The excision of the sciatic nerve *in toto* predicates the elimination of all motor and sensory transmission throughout the area supplied by the sciatic nerve and its derivatives. The nerve was divided at the level of the gluteus maximus and the first branch delivered to the hip-joint was probably untouched. The muscular branches distributed to the flexors of the leg—namely, the biceps and semimembranosus and semitendinosus and the branch to the adductor magnus—were divided. These muscles afterward wasted and showed a state of flaccid atrophy. The area of sciatic sensory distribution was entirely cut out. In addition to the hamstring group of muscles already mentioned the muscles supplied by the internal popliteal nerve—namely, the gastrocnemius, plantaris, soleus,

and popliteus, were deprived entirely of their nerve supply, wasted rapidly and showed the reaction of degeneration. The flexors of the foot, tibialis anticus, the extensor longus digitorum,

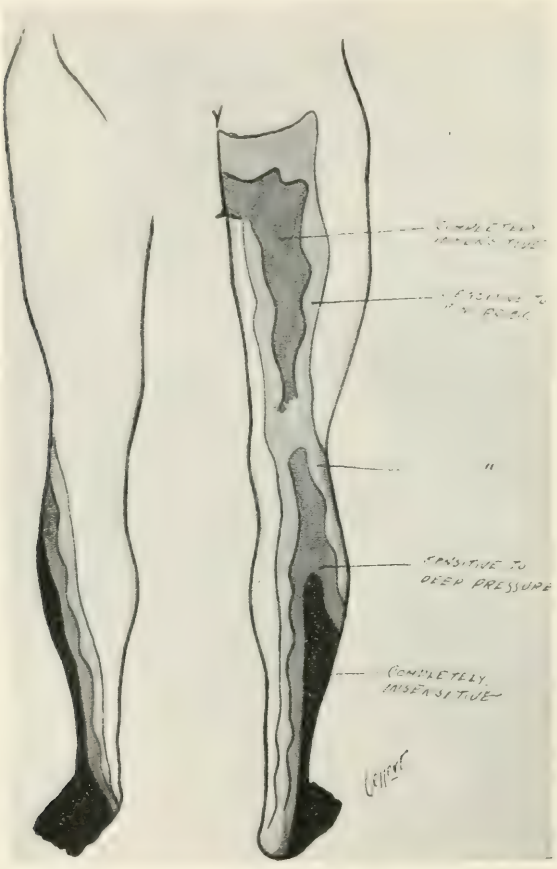

FIG. 3.—Zones of disturbed sensibility in Case 1.

extensor longus hallucis and peroneus tertius were shorn of their nerve supply and underwent the same paralytic changes. The extensors of the foot—namely, tibialis posticus, flexor longus digitorum, the flexor longus hallucis—were similarly involved

and likewise the peroneal group and all the groups of smaller muscles of the foot.

Previous to this operation it was held doubtful that regeneration could take place when the substance of the nerve is lost over a spread of two inches or more. Here a gap of ten and three-quarter inches was made and the entire trunk of the sciatic eliminated. The theory has been held for a number of years past that regeneration can only take place from the central end of a nerve, and more recent studies would tend to confirm this principle.

That regeneration on a colossal scale can take place and has taken place under conditions in which flaps taken from the peripheral ends of a divided nerve and utilized to bridge a gap ten and three-quarter inches in length and fixed to the central end of the divided nerve, and that they were successful in restoring motion and power to muscles completely paralyzed by the trauma, is manifest in view of the results obtained in this case and listed as follows: (1) Trophic recovery is practically complete. (2) There has been recovery in a limited degree of protopathic and epicritic sensibility. (3) There is almost universal recovery of deep sensation. (4) Recovery has taken place of motion and power in groups of muscles which, after the excision of the nerve, were reduced to a hopeless paralytic state: (*a*) the flexor group in the thigh, viz., complete recovery of the semimembranosus, semitendinosus and the biceps; (*b*) the flexor group in the leg, viz., the gastrocnemius, plantaris, soleus and popliteus; extensive recovery has taken place in this group which has been progressive; (*c*) the flexors and extensors of the phalanges and foot; minute examination of these muscles show them to be strong and capable of contracting and while they do not move the foot they control it and there is but little tendency to foot-drop; some of the muscles of this group now show only partial reaction of degeneration. (5) The relatively small and contracted area of absolute cutaneous analgesia. (6) The relatively small area of thermic analgesia. (7) The direct sensibility of the new track of the nerve to deep pressure and the transmission of painful sensibility

thereby to the foot. (8) Possession of muscular sense. (9) Independent and unaided locomotion; the man can not only walk long distances but can run at considerable speed.

The citation of the first case leads one to consider another in which a complete reversal of the methods was resorted to—namely, the utilization of central instead of peripheral flaps. Obviously no other method of treatment could be considered than the use of nerve flaps whether auto-, homo-, or heterotransplants. The second case refers to one which, because of a gunshot wound becoming infected, resulted in the formation of so much scar tissue as to lead to the destruction of a considerable part of the sciatic nerve and its two branches. So great was the destruction that a segment of four inches of the main trunk of the sciatic together with three inches of each branch had to be thrown in the discard. Although the results were not nearly so successful as in the first case, because of qualifying conditions of unusual character antecedent to my operation over which I had no control, its salient features support the principles which the first case established.

K. W., aged twenty-five years, a very rugged type, sustained a gunshot wound of the left leg in September, 1915, with a thirty-forty expanding bullet. The bullet entered through the tendon of the biceps and came out through the popliteal space, completely severing both the internal and external popliteal nerves. There was complete sensory and motor paralysis of all the parts supplied by both nerves.

An operation was performed for the relief of this condition by his surgeon, Dr. F. B. Bogardus, of Montana. Great care was exercised in this operation and the attempt was made to unite the divided ends of both nerves. Unfortunately the elements of infection were in the wound and the operation failed in its purpose. After several months the wound healed but left a very extensive zone of dense scar tissue which occupied and extended beyond the popliteal space. The leg had a very forbidding appearance, due to severe trophic shock; it possessed no power of motion at the knee because of contractures of tendons and

scar-tissue contraction. The trophic changes were very striking, especially in the region of the foot; the skin was harsh, purple and mottled and covered with superimposed epithelial débris and vulnerable to the slightest injuries. Locomotion was possible under difficulties with the use of brace and crutch.

The muscles were found to exhibit the reaction of degeneration. The spread of the area of sensory paralysis was delimited before the operation and was found to correspond closely to the normal distribution of both nerves.

The first operation was performed May 17, 1916, and the approach to the divided nerves made in the center of the popliteal space. The nerves were traced with difficulty and found immured in dense scar tissue. They were literally dug out of their respective beds and tracked upward and downward to levels at which both nerves presented a normal appearance.

In the upward direction it was found that the main trunk of the sciatic was densely held and compressed in scar tissue for a distance of five or six inches. The internal popliteal was found to consist of nothing but fibrous tissue over a distance of three and a half inches. It was resected at levels which showed at either end nerve fibers. The corresponding segment of the external popliteal presented a very fair appearance and was left intact. The gap made in the internal popliteal was thereupon bridged by a flap taken from the sciatic, carrying with it eight to ten fibers of that nerve. The technic of this important step will be referred to at a later period in this report.

Both the repaired nerve and its fellow were then invested by a jacket of fascia lata over the areas involved and the wound closed after section of the hamstring tendons and a resection of as much of the scar tissue as safety would permit. The wound healed very well but because of the scar tissue and trophic disturbance a skin-grafting operation was done June 26, which improved the conditions. The patient was discharged July 11, 1916, and sent to his home in Montana, with instruction for treatment. On October 17 of the same year he reëntered St. Vincent's Hospital, and it was found that only a very minor degree of improvement

had taken place. There was no recovery of sensation or motion. There was, if anything, greater atrophy of the muscles and trophic disturbance, while improved, was still severe.

Realizing the failure of the first operation a second was proposed, based on the assumption that a much better result would be obtained by an operation in which the drawback of scar tissue could be excluded and the nerves placed under conditions in which regeneration and recovery of function would be favored.

Accordingly, on October 17, the popliteal space was reopened and the sciatic nerve and its branches exposed once more. Once more they had to be taken out of their bed of dense scar tissue. The sciatic nerve over a distance of seven or eight inches above the popliteal space was released from its connections, to which it was held by numerous adhesions. Those parts of the nerve, which were enveloped in fascia lata at the former operation, were found hopelessly matted in scar tissue. The lower end of the sciatic was palpated and was found to be compressed and condensed into scar tissue. Accordingly the last three inches of the main trunk of the sciatic and two and a half of both popliteals were cut out and thrown in the discard. For some distance above and below these levels the nerve trunks were found intimately adherent to the subjacent tissues.

The operative procedure. The sciatic nerve at a level of three inches above its bifurcation was divided and no nerve filaments being observed a series of cross-sections were made up to a level which displayed nerve fibers. Ultimately the sciatic nerve had to be divided at a level four inches distant from its bifurcation. The internal and external popliteal nerves were treated in like manner and both divided at levels three and a half inches distant from the bifurcation. It was now evident that no system of treatment could be considered which would place the nerve elements in their normal anatomical position.

It was therefore decided to treat the divided nerve and bridge the large gap by a compound neuroplastic operation performed in a field remote from the zone of scar tissue. Two flaps containing six to eight nerve fibers, eight inches in length, were detached

from both divisions of the trunk of the sciatic nerve by the following method: An ordinary slender silver probe, in preference to a cutting instrument, was thrust through a section of the trunk of the sciatic nerve between normal lines of cleavage and made to include the desired number of fibers. By a splitting process these fibers were separated downward to a level half an inch distant from the truncated end and the upper end of the split portion was then cut and the flap placed for the time being in a warm compress saturated with normal salt solution. A like flap was made from the other section of the trunk of the sciatic nerve and similarly treated. The next step consisted in anastomosing the popliteal branches. The same type of probe was used to make a cleft half an inch in length in the internal popliteal nerve one inch below its truncated end and into the cleft the end of the external division was carefully tucked and held in position by two or three slender iodized catgut sutures.

In order now to safeguard these delicate nerve flaps from the fate of destruction by scar tissue the following maneuver was resorted to: A long, slender, curved, probe-pointed dressing forceps was passed through the muscular tissues as far afield as possible from the zone of scar tissue in the popliteal space; the forceps was caused to traverse the inner head of the gastrocnemius and semimembranosus and on the outside the outer head of the gastrocnemius and the biceps muscles. The end of the forceps was made to emerge at or about the level of the stump of the sciatic nerve. With the forceps the end of the outer filament was first seized and drawn through this muscular tunnel and sutured carefully to the truncated end of the internal popliteal nerve. By a similar maneuver the external filament from the sciatic was placed in its new muscular bed and its end in a cleft previously made on the outer aspect of the external popliteal nerve half an inch from the point of anastomosis. The wound was then closed and united throughout by first intention. The leg was placed in a position of midflexion and was held there in a plaster cast. As soon as possible after the operation treatment by massage and electricity was instituted and continued for many months (Fig. 4).

Inspection made during the month of May of the present year, two years after the last operation, revealed the following con-

FIG. 4.—Showing gap created by resection of segment of sciatic nerve and its branches destroyed by scar tissue; scheme of formation of central flaps and plan of avoiding scar tissue by tunnelling contiguous muscles for sequestration of nerve flaps; scheme of suture by (*a*) anastomosis of external popliteal into the internal popliteal nerve and (*b*) central flaps to their corresponding popliteal nerve ends. (Case 2.)

ditions: There is a striking change in the appearance of the entire leg, the color and texture of the skin look normal and the

muscles are well rounded and developed. There is no trophic disturbance. Four or five months following the operation there was a response on the part of some of the muscles of the leg to the faradic current, with slight movement of two or three of the toes. This very limited movement passed away in two or three months. Locomotion over a distance of four or five miles without adventitious aid can be easily accomplished. There has been moderate recovery of epicritic and protopathic sensibility. Deep pressure

FIG. 5.—Zones of disturbed sensibility in Case 2.

is felt over the area of the distribution of both popliteal nerves and transmitted down the leg. There is excellent control of the foot and the leg on locomotion, permitting only a very slight tendency to foot-drop. There has been no recovery of motion in the muscles supplied by the internal and external popliteal nerves. Notwithstanding, improvement in locomotion has been progressive. The foot is still vulnerable at points where the footwear presses unduly (Fig. 5).

Concerning this case it is only fair to say, in estimating its values, that it presented from the beginning grave and almost insuperable difficulties. Infection was virulent and prolonged and invaded intimately the sciatic nerve and its branches over long stretches. They were compressed by the surrounding tissues and adherent to them. Their sheaths had lost their luster and were thickened, and doubtless the perineurial connective tissue investing the axis-cylinders was the seat of cell proliferation. The material that entered into the formation of the flaps therefore was of very doubtful quality.

Notwithstanding these drawbacks it is perfectly clear that extensive regenerative changes have taken place in the leg and that they are still progressive. Reasoning from analogy, basing the reasoning upon the results obtained in the first case in which not only individual but large groups of muscles were restored to power and function by the use of very long and slender peripheral flaps, it is held that under like favorable conditions—namely, early and timely operation and the use of sound central flaps—a larger measure of regeneration and recovery of function would undoubtedly have taken place.

The third case illustrates the possibility of bringing about recovery of function in a divided nerve in the presence of infection in which there was a discharging sinus and bone necrosis.

O. I. entered my service in St. Vincent's Hospital, June 18, 1915, suffering from an ununited fracture of the right humerus, the result of a compound comminuted fracture sustained four months previously, when she was thrown from her horse. In addition to the fracture there was complete division and paralysis of the musculospiral nerve.

An operation performed in Victoria, B. C., to reduce the fracture and restore the divided nerve, failed in its purpose. Infection of the arm was present. On entering my service a sinus was found at the junction of the upper with the middle third of the humerus leading to dead bone. There was also considerable infection, with discharge. The musculospiral nerve was found to be completely paralyzed. Incision revealed a necrosed segment

of the humerus an inch in length resting between the fractured ends, preventing union. The musculospiral nerve at both ends was found to lead into dense scar tissue. A fragment of bone was removed, the ends of the humerus delivered and the end of each fragment resected. They were approximated and held by a steel plate.

It was then found that the gap in the nerve was too long to allow its approximation. Accordingly a flap one and a half inches in length was made from the central end and made to bridge the gap and sutured to the other end of the nerve, which was previously cross-sectioned until it showed the normal nerve fibers. The involved area was then surrounded by areolar tissue taken from the arm and invested by the underlying muscular fibers by an overlapping suture. A small cigarette drain was inserted and held in position for twenty-four hours and the arm invested in a plaster cast. The wound healed quickly thereafter.

It was reported, eight months afterward, by her father that the hand could be lifted from the wrist into its correct position, and within fifteen months this young woman was taking the massage course at McGill in war service, doing her practical work at the Montreal General Hospital.

This case illustrates two striking features: (1) that recovery may take place as a result of the use of the flap operation in a small peripheral nerve; (2) that the operation can be performed sucesssfully in the presence of infection. It suggests the important principle that the peripheral nerve when divided should be immediately restored whether in the presence of infection or not. It illustrates that in compound comminuted fractures associated with infection caused by violent injuries, successful results may be achieved in the reconstruction of a member that is badly shattered by the recognition of these principles.

This is the case for neuroplasty so far as this study is concerned. It is inconceivable that any other method of handling these cases could have brought about equivalent results. Many military surgeons oppose resort to this method and depend, except when suture can readily be effected, upon steps to release nerves when

found involved in adhesions, scars or otherwise, and upon repairing them by devices of different kinds designed always to bring about their coaptation and suture end to end. With this purpose in view joints are flexed, bones shortened, nerves deviated and other methods used to bring about the approximation of the divided ends.

What is to be done in many cases of nerve trauma in warfare in which gaps are so great that the means referred to will not suffice? Are they to be left to their fate and denied any offer of reconstruction or repair? Is there not a place in very large breaches in nerves for the autotransplant, the homo- or heterograft? Is there a place for neuroplasty in such cases? Is the experience recorded in these lines fatuous and misleading?

The study of these cases furnishes an opportunity for reflection on many phases of regeneration as they affect such delicate structures as nerves. We are aware that sensation, motion and other impulses are transmitted through nerve trunks along definite paths, each fiber possessing a definite and limited function. There would seem to exist, however, other forces than these which pass through nerves which have not yet been explained and which play an important role in regeneration. Thus the first two cases demonstrate the transmission of a force which governs nutrition and quickly arrests trophic shock. The effect is almost immediate and very striking. They also demonstrate that muscular tone follows promptly upon the splicing of a divided nerve. The muscles without having motion develop a certain firmness, fulness and roundness and cease to undergo atrophic changes. Other influence might also be mentioned.

Nerves are generally found in contact with muscle, and muscle is naturally the protective environment of the nerve. The injured nerve, when the process of repair begins recoils from contact with all tissues save its own. In muscle it finds a congenial soil for the reason, perhaps, that the first tendrils given off by the regenerating nerve find in the mesh of the muscle many fine little filaments with which it can establish relations. In any event it seems certain that the muscle undergoes quick changes in form

and substance if not in function as a result of the early repair of a divided nerve.

Objections are urged by writers to the mutilation of any nerve tissue for purposes of repairing damaged nerves. This would seem to be a mischievous law to lay down, especially in the case of large gaps in nerves. It would deny the surgeon access to nerve trunks above or below the gap. What, after all, is the value of the sciatic trunk above a large gap? Is it not in great part like the branches below the gap without function and useless? What is more natural than the assumption that each tissue must furnish its own reparative material for its successful repair. Why should a different law apply to the nerve than to the tendon, muscle or bloodvessel? Why not utilize the trunk and its branches in all cases as freely as possible to repair large gaps in nerves in order to attain the maximum degree of regeneration and recovery of function?

The note sounded in the treatment of these cases by recent writers condemning these methods does harm to the cause of nerve surgery and might seriously affect the future of crippled soldiers who urgently need nerve repair as a means of their reconstruction. It is here urged that caution be always used in all cases of the kind under consideration looking to the utilization of nerve tissue that is known to be sound, that the utmost delicacy and tact be used in the handling of these delicate structures and that the region affected, especially the neighboring muscles and joints, be always placed in an ideal state for their recovery.

The study of this limited group of cases would seem to warrant certain deductions—namely, (1) that regeneration and recovery of function are promoted by the use of nerve flaps; (2) that both central and peripheral flaps can be used for such purposes; (3) that a peripheral flap, by laying down a nerve path, may promote regeneration over a great gap in a nerve trunk, in one case quoted ten and three-quarter inches long; (4) that the approximation of nerves and their repair should be done in all cases with the least possible delay (this would apply as well to infected as to clean cases); (5) that the arrest of trophic shock can be promoted by

early closure of large gaps by flaps; (6) that unimpaired nerve tissue should always be utilized for the effective repair of damaged nerves; (7) that in their repair nerves can be successfully sequestrated in muscular tissue so as to promote their own regeneration and that of the muscles in which they are embedded; (8) that the principle of sequestration can be utilized in proper cases so as to avoid infected zones in wounds and also scars and other obstacles to nerve repair.

DISCUSSION

Dr. Charles L. Gibson, New York City:

I want to approve Dr. Mackenzie's method, as I know the general tendency abroad in war surgery is to discard flaps, using either end-to-end anastomosis or transplantation.

Dr. Kenneth A. J. Mackenzie, Portland, Oregon:

The recovery of function in the second case was not so striking as in the first case, the flaps being brought from impaired nerve tissue. But if I succeeded in obtaining such a tremendous degree of recovery of function from flaps from peripheral nerves, had I not every right to anticipate a greater majority from secondary flaps? There is a great deal to be said in favor of these flaps, and I am amazed to find in monographs on military surgery an effort to utilize autotransplants, and that flaps are being condemned by surgeons. In one of my cases is shown the wonderful value of these flaps: the flexors of the thigh, absolutely paralyzed the sciatic and lesser sciatic, and the use of these flaps in eighteen months produced complete recovery of the hamstring muscles and flexors of the leg.

AMPUTATIONS OF THE LEG

By INGERSOLL OLMSTED, M.D. (Tor.)
HAMILTON, ONTARIO

How little we thought in 1914, when the International Society of Surgery met in New York City, that the world was soon to be plunged into a terrible war; yet Dr. Depage anticipated it, as indicated by his Presidential Address on War Surgery.

The large number of poor fellows who have returned from the front with mutilated bodies, many of whom will require amputations or reamputations, urges one to do everything possible for the future comfort of these men, and only those who have lost a leg appreciate the importance of having a good, useful stump.

Many years ago Lister reported a patient with amputation of both legs who was able to dance the Highland fling. Subsequently, artificial limbmakers induced the surgeons to pay little or no attention to providing an end-bearing stump, as the socket of the limb took the weight of the body on its upper and inner surfaces. Fortunately, during the last few years, the importance of an end-bearing stump has been recognized.

Everyone acknowledges the advantages of high division of the nerves, sawing the bones at right angles to the vertical axis of the body and the accurate junction of the flaps; yet how often are these simple rules neglected. No operation has received less attention by the general surgeon than that of amputations.

A great advance was made when Bunge advocated the removal of a small portion of the periosteum and marrow from the ends of the divided bones. This prevented the formation of bony spikes, which caused pain when pressure was brought on the end of the stump.

The success which the aperiosteal method of treating the bone has given, practically eliminates all other methods with the exception of the Stokes-Gritti operation at the knee-joint. In this operation the condyles of the femur and the posterior surface of the patella are removed with the saw. The patella is then placed on the end of the femur, so as to approximate the two sawn surfaces. A bony union takes place and an excellent end-bearing stump is produced.

Amputations of the lower extremity should also be done by experienced surgeons and every detail carefully remembered, just as in breast or stomach operations. The flaps should be just long enough and trimmed so as to come together accurately, with the junction behind the end of the stump. Excess of skin is almost as bad as too little, as it becomes folded and chafes when a sock is drawn on and a leg worn. The nerves should be divided high up, so as not to become involved in the cicatrix. A neuroma in a stump gives most troublesome sensations and will usually require further operative work. Strip every vestige of periosteum a distance of a quarter inch above the point of division of the bone. Divide the bone at right angle to the vertical axis of the body and take off the sharp edges. Scoop out the medulla to a point corresponding to the division of the periosteum. If the amputation is below the knee, divide the fibula obliquely and at a little higher level than the tibia, so that the stump may be more or less conical. Careful hemostasis, a few strands of catgut for drainage and horsehair for sutures complete the operation. Dr. Malloch, of Hamilton, a pupil of Lord Lister, always used No. o catgut for his ligatures, and he ligated the vessels only and not a mass of tissue as well. He eliminated dead spaces by sutures and used only small drains of catgut. His results were excellent, and I have endeavored to follow his teaching. Silkworm gut should never be used to approximate the flaps, as their rigidity causes the patient pain when the dressing becomes shifted. This is a small point, yet, if acted upon, will prevent the patient having many a restless night.

The subsequent treatment of the stump is most important.

Lyle, in this country, specially deserves credit for advocating the early massage and use of the stump in order to prevent atrophy of the muscles. It will take some time to teach limb-makers to refrain from giving instructions to their customers to bandage the stump in order to make it atrophy. A long stump of the leg, unless possessing a good end-bearing, will undoubtedly become objectionably cold when enclosed in an artificial leg. Many such have been reamputated. Syme obtained excellent results with his amputation at the ankle, but the modern leg makers objected to so long a stump and the operation became unpopular. The longer the stump the better control the patient has of an artificial limb and the more pressure he can bear on the end of the stump the less trouble he will have from callosities caused by the lateral bearings of the socket. If care be taken to encourage the patient to bear pressure on the end of the stump he will be rewarded by being able to bear the whole weight of his body on it in a very short time. The daily massage, exercise, bathing and rubbing with alcohol will harden the skin and prepare the stump for a temporary leg. These exercises should not be started before the stump is healed. Pressure can then be made on the end of the stump by the nurse several times a day. Then the patient is encouraged to press the end of the stump against a padded box or chair. In a very short time he will be able to bear nearly the whole of the weight of his body on this stump. A temporary leg may then be used, as advised by Lyle, but I prefer to have a permanent leg fitted so soon as possible. The stump will shrink and the socket will require relining, but the patient will sooner learn a natural gait. In spite of all one's care and instructions to the patient we will usually find him fitted with a limb without an end-bearing block. This has been my experience, and hence the deduction that surgeons, as a rule, either do not know of the importance of an end-bearing stump or else they do not take the trouble to enforce their instructions.

The subsequent welfare of the patient must always be remembered, and a very short stump below the knee will not swing a leg properly, no matter how good an end-bearing stump may be

obtained. The end of the stump at its front part will become abraided by constant friction, caused by the attempt to swing the leg forward, for this cannot be done by the supporting band around the shoulder, hence a Stokes-Gritti operation through the condyles of the femur appears to me far preferable to the operation recommended by Felix Franke. The patella and the skin covering it have early become accustomed to bearing the weight of the body, and a good limbmaker can easily fit a limb where this amputation has been made.

Kineplastic amputations suggested by Vanghetti are, in my opinion, not applicable to the leg, as an end-bearing stump cannot be satisfactorily obtained. Too much stress cannot be laid on the advisability of a good end-bearing stump, and an expert limbmaker can produce a foot with natural and useful motions which will more than compensate for any supposed advantages of the kineplastic operation here.

One point more worthy of mention is that stumps that are too tender and cannot allow pressure on the end may, in the majority of cases, be educated to permit considerable pressure without causing discomfort. When the skin of a stump is tender, specially marked in patients in whom amputation has been performed in the middle or later periods of life, a short stump sock, made of Angora wool, will give greater comfort to the patient than any other sock I have tried. The French wool is much superior to any made in this country, but, unfortunately, now it is almost impossible to obtain the French article.

DISCUSSION

Dr. Willy Meyer, New York City:

Whoever has watched the results of the Pirogoff amputation or of osteoplastic amputations must have been impressed by the great value of the end-bearing stump. Ever since the subject of the aperiosteal stump was discussed at the International Surgical Congress in New York City in 1914, I have taken great pains to follow this plan in all my amputations. In passing, I may say that I did Bier's osteoplastic amputation on the humerus as well as on the femur and leg and was perfectly satisfied with it. The end-bearing stump method, however, is much simpler and gives most satisfactory results. After primary union of the wound, massage of the stump is instituted early, while the patient is given a hard object, such as the seat of a wooden chair upon which frequently to lean his weight on the stump; soon a peg leg, as advised by Lyle, is attached.

I rose particularly to call attention to the fact that those who are making artificial limbs must change their methods. Up to the present, all artificial limbs, for instance, for amputation of the femur have been made with the patient's pelvis resting on the prothesis. But now there is a possibility of such patients standing on their own feet, so to speak, once more, which is of most unquestionable advantage. With an imperfect support of this type a young girl patient was able to dance a two-step. What would she have been able to do had she had a properly fitted artificial limb? We should all take pains to teach those who are making artificial limbs how best to adapt them to the end-bearing stump.

Dr. Charles L. Gibson, New York:

To emphasize points brought out by Dr. Olmsted as applied to warfare, I would say that I have had occasion to see a large number of cases of Tuffier's in the Maison Blanche. He made a careful analysis of the main causes of unsatisfactory results, and I think the largest number falls in the category of defects in the bony section. In many cases it is due to the fact that the fibula is sawed at too low a level. In many cases by careless or accidental handling of the periosteum there has been left a little bridge of periosteum, which has remained loose and from which a secondary ossification has formed later. It is wise therefore always to take an *x*-ray to discover any such mechanical obstacle. Now, with regard to the importance of the early use of the stump. The muscles in the stump need exercise. I would say that

Depage fits his patients with a temporary stump as soon as the wound is closed; he then makes them walk and does not allow a crutch in the hospital.

Dr. A. J. Ochsner, Chicago:

I wish to call attention to a little plan of helping patients who have a tendency to callous formation on their stumps. It is to put a woollen stocking next to the stump and then cover this with a silk stocking. The woollen stocking adheres to the stump and slides on the silk stocking, which is smooth.

Dr. W. L. Estes, South Bethlehem, Pa.:

I am very much interested in this subject of amputations, as I have had to do a great many. With reference to the Bonar operation, out of 776 amputations, of which we have record, I think there were not more than twelve done by this method, and these have shown no better results than those which had only the ordinary periosteal flap to extend over the whole anterior surface of the sawed-off bone. As regards the leg, Dr. Olmsted has brought out the point of making a conical stump by severing the fibula at a higher level than the tibia. When this is done there is really no trouble with the stump, provided the flaps are adequate and well fitting. In most other instances it is fibrous tissue which brings about the evil resulting from disordered or ill-placed flaps or badly adjusted flaps, and it is the contraction of this fibrous tissue which produces the pain or some trophic disturbance resulting in ulcers. If the nerves are cut off at a high enough level so as not to be caught in the contracting fibrous tissue the stump rarely is painful. As regards the weight-bearing, education of the stump should begin at once. Graduated pressure should be begun from the time of adhesion of the flaps and continued until the patient is able to have some prosthetic appliance adjusted.

Sir Arbuthnot Lane, London, England (by invitation):

My point is a protest against amputation. If you talk with a British Tommy and ask what kind of a stump or what sort of an apparatus he wants he knows exactly. Suppose he has to have two amputations, one of the thigh and one of the leg; then he wants something done that will make him look decent like his fellows. The British soldier is in no doubt as to what he wants. An amputation through the middle of the leg and through the middle of the thigh will give a very fine limb. A long way the best thigh splint is made by Desucre, a Frenchman, who was a son of a man who lost his leg

and went through the usual sequence of artificial limbs. Desuere has made a beautiful limb of aluminum with a roller-joint covered with leather that lasts forever and it has every possible advantage.

As to the fibula, we always divide it at high level to produce an end-bearing stump. My point against amputations is that many are done unnecessarily. I want to call attention to the unnecessary operations done. Take a man shot through the knee with a lot of bone carried away. If you excise this knee-joint there will necessarily result a stiff leg. In the civilian's life there is no room for a stiff leg. Have you been in a tea-room with little round tables and watched a man with a wooden leg? If he gets into a train he is particularly conspicuous. This really is an exceedingly important point. You know our friend Horsley. His daughter's fiance was shot through the leg, four inches of the femur being carried away. He is an exceedingly intelligent man, and he came to me with the proposition that one of two things should be done. He asked: "Do you think it would be better that I have an amputation and wear an artificial limb or should I have a graft put in and get a stiff leg?" I said to him: "There is no hurry, so suppose you talk with some other officers and men who have gone through the same experience. Talk to the men with the stiff legs, confining yourself to officers." He made inquiries and came back and said: "Lots of men who have had amputations through the thigh are dissatisfied after a little time and not infrequently discard their artificial limbs. About the stiff knees, I am in no doubt that the man with the stiff joint tries to make the best of it, but is a nuisance to himself and his fellow creatures." So I said to him: "Very well, we will make a hinge-joint with a ring catch." Now, then, whenever he wants to sit down he does it like an ordinary creature. He told me that during his honeymoon he could walk seven or eight miles without difficulty. The advantage of the movable joint is enormous. Any number of legs are amputated because the surgeon finds that he cannot bring the end of the tibia in contact with the femur, and therefore instead of doing the man a good turn by giving him an artificial joint, he is doing him irreparable harm and making him a nuisance to the community. Sometimes it is a considerable expense. The same thing applies to the elbow. When the war began we were deluged with cases until our friend Wilms taught us how to incise joints. He simply incises the joint, taking out the loose pieces of bone and trusts to the rest of the bone performing its function, taking no antiseptic precautions, and closes it. We have the silly idea that rest is an important thing. He institutes early movements of the limb and considers voluntary movements very essential.

Dr. Ingersoll Olmsted, Hamilton, Ontario:

Doctor Ochsner's suggestion of wearing a silk stocking between the first and second stump sock is a good one. This would assist in preventing the inner sock being displaced. It is always advisable to wear more than one stump sock. There is another point in connection with the technic of the stump upon which I do not think enough stress has been laid, and that is the fitting of the flaps: get them to come accurately together.

THE VALUE OF THE TRANSFUSION OF BLOOD IN THE TREATMENT OF THE WOUNDED IN WAR

By A. PRIMROSE, C.B., M.B.C.M. (Edin.), Colonel, C.A.M.C.

Two years ago, in conjunction with my colleague, Major (now Lt.-Col.) E. S. Ryerson, I read a paper at Salonika on this subject before the Salonika Medical Society. The society was composed of members of the Royal Army Medical Corps and of the Canadian Army Medical Corps, then stationed in Macedonia; we also had a few French medical officers as visitors. We had had a few cases, in which transfusion was employed, in No. 4 Canadian General Hospital at Salonika. The first of these was on Christmas Day, 1915, when a man suffering from a compound comminuted fracture of the upper third of the femur was admitted in a desperate condition suffering from shock and hemorrhage. We believed his life was saved by transfusing 815 c.c. of blood from a fellow-patient in our tent hospital. A second case, in which hemorrhage threatened to prove fatal, was transfused with 1100 c.c. of blood. Both of these patients made good recoveries and were reported in our paper, which was subsequently published in the *British Medical Journal*, September 16, 1916. Subsequently some 8 cases were transfused in our hospital at Salonika. Unfortunately the hospital records are not available for the purposes of this paper and I cannot give the details, but it is worthy of note to observe that in one of these hemolysis occurred, and the patient, after transfusion of 200 c.c., showed embarrassment of respiration, puffiness of the face and eyelids, with marked congestion of the

conjunctivæ, so that the transfusion was of necessity stopped and the patient subsequently succumbed. This case illustrates the necessity of preliminary tests of the blood of the donor and of the recipient to prevent, if possible, such an occurrence by determining whether or not hemolysis is likely to occur.

Early in the war surgeons were tardy in recognizing the value of transfusion of blood as a life-saving measure in cases of hemorrhage in the wounded. In April, 1917, Colonel Cuthbert Wallace gave us a most valuable contribution to the literature of the surgery of the war in his analytical study of 1200 cases of gunshot wounds of the abdomen. While recognizing that "hemorrhage is the greatest enemy of the surgeon," he makes the following comment:

"The treatment of hemorrhage after operation is not satisfactory and repeated saline infusion is powerless to prevent a fatal issue. Transfusion of blood and of citrated blood has been tried and papers have been published by Major Edward Archibald and Captain L. Bruce Robertson of the Canadian A. M. C. These cases are as yet too few to enable an estimate to be made of its efficiency in the class of cases under discussion."

In Robertson's series of 68 cases, which I am about to quote, there were 5 of wounds of the abdomen. Of these 4 died, 1 of gas-bacillus infection, 1 of hemolysis and 2 who were in a desperate condition after operation showed only temporary improvement after transfusion, and finally succumbed to their injuries. The success attained, however, in the fifth case illustrates the fact that at all events the element of hemorrhage as a cause of fatality may be eliminated, provided the bleeding-points can be secured. The case was one in which abdominal injuries were complicated by a fractured femur. The spleen and the bladder were torn. Splenectomy was performed and the bladder sutured. Transfusion of 1000 c.c. of blood was then accomplished. The systolic blood-pressure rose from 80 to 185 mm. of Hg. The patient made a complete recovery and was heard from as convalescent some weeks after his arrival in England.

In civil practice, among the surgeons of this continent, prior

to the war the immense value of the transfusion of whole blood in cases of hemorrhage was established in hundreds of instances in which it had been employed. Many patients in a desperate condition from severe hemorrhage have been first transfused and then carried through serious major operations successfully and have subsequently had a normal convalescence leading to complete recovery. One may quote a single case from the writer's experience of a woman, aged forty-two years, suffering from a fibroid tumor of the uterus. She was admitted to the hospital blanched and pulseless, with a red cell count of 1,800,000 and hemoglobin 15 per cent. She was restless, with sighing respirations. By transfusion from her son we gave her 820 c.c. of blood and performed an immediate hysterectomy. She made an uninterrupted recovery. Numerous other examples might be cited, cases of severe gastric hemorrhage, hemorrhage from various forms of traumatism, etc., in which patients were admitted to the hospital in a critical condition from hemorrhage. Such patients when transfused became good operative risks and were in many instances carried safely through serious operative procedures.

Then, again, in prewar times the value of transfusion in cases of secondary hemorrhage has been demonstrated many times. My first case of this kind was eight years ago, when a lad, aged twenty years, was admitted to my service in the Toronto General Hospital. He had cut the calf of his leg with an axe ten days previously, severing the posterior tibial artery, and was in a critical condition from secondary hemorrhage. Blood examination showed 2,850,000 red cells, with 40 per cent. hemoglobin. His brother served as donor and he was transfused. Crile's cannulæ were used for the purpose. The wound, which was in a sloughy condition when he was admitted, healed rapidly after transfusion and the patient recovered. Transfusion in such cases of secondary hemorrhage increases the coagulability of the blood and improves the local resistance of the tissues to infection.

Facts proving the value of transfusion of blood in hemorrhage, and more especially in hemorrhage accompanied by shock, have been firmly established. Since it was first done by the Canadians

in the early months of the war it has become gradually more and more employed on the battle-field, until today it is very extensively used on the western front not only by the Canadians but also by the British Imperial Service. More recently the Americans, who had proved its value long before war broke out, have promptly utilized the transfusion of blood as a life-saving measure among the wounded men.

One of our Canadian officers, Captain H. E. Clutterbuck, has furnished me with records of certain cases transfused by him when serving in an imperial casualty clearing station. I may quote two of these as typical examples.

January 16, 1918, a private was admitted suffering from multiple shell wounds: the right forearm was shattered, the left humerus fractured, the right femur broken and the femoral artery was ruptured just above the popliteal space. There was also a through-and-through wound of the left foot, fracturing the fifth metatarsal bone. He was admitted twelve hours after receiving his wounds. He was very cold, very pale and very quiet. The pulse was imperceptible, the temperature was 98 and respirations 28. He was transfused ten hours after admission, with 500 c.c. of blood by the use of Kimpton's tube. Immediately afterward the wounds were all cleansed by free excision of all damaged tissues, amputation was performed through the right thigh, the operation taking fifty-five minutes. His pulse after operation was 116 and his systolic blood-pressure 80; next day it rose to 120. He steadily improved; by the fifth day the pulse had fallen to 90 and the wounds were all doing well. He was evacuated to the Base on the sixth day after operation.

A second case was that of a private admitted in January, 1918. A bomb had exploded at his feet and blown off his right foot just above the ankle and also fractured both bones of the same leg at the upper third. On admission he was cold, pale and pulseless; he was conscious but very quiet. Warmth and restoratives were employed and 3 pints of normal saline were given subcutaneously. After some six hours the body warmth was somewhat restored and the pulse became discernible, and was counted with difficulty

at 130. He was then transfused by the direct method for twenty minutes, with whole blood from vein to vein, using Fullerton's tubes for the purpose. The leg was then amputated under chloroform. He was evacuated to the Base six days afterward in good condition. In this case the blood-pressure was recorded at 54 mm. of Hg. at the beginning of transfusion. It rose to 164 when transfusion was stopped and dropped to 108 during the operation. One hour after the operation it had again risen to 150 mm. of Hg.

Major L. Bruce Robertson, who was on duty in a Canadian casualty clearing station in France, published in the *British Medical Journal*, November, 1917, the details of 36 cases in which transfusion was done in hemorrhage. More recently he has prepared a paper, which will soon be published, detailing his complete series of 68 cases. He has permitted me to refer to his results and the analysis he has made of the cases in his forthcoming publication. Other cases of transfusion were done in the same clearing station, bringing the total number in that particular hospital unit up to something over 100. Major Robertson's cases were classified as follows:

1. Primary hemorrhage:		
Life saving (evacuated to Base Hospital in good condition)		36
Immediately beneficial but died from:		
Shock	8	
Gas gangrene	5	
Capillary bronchitis	1	
Pulmonary embolism	1	
	—	15
No benefit		4
Harmful (hemolysis)		2
2. Secondary hemorrhage		9
Of these 6 recovered and 3 died. Of the 3 that died 1 death was due to hemolysis following a second transfusion. One died of gas gangrene three days after transfusion. One died of streptococcus septicemia one month after transfusion.		
3. Severe carbon monoxide poisoning		2
Grand total		68

The 2 cases of carbon monoxide poisoning were men who were buried in a dugout in which certain combustible material caught fire. Venesection with the removal of 1000 c.c. of blood in two stages gave moderate relief, but their condition remained grave. On this account 1000 c.c. of blood were transfused. This did not appear to produce any immediate effect, but the following day improvement was evident and the patients recovered.

The casualty clearing station at which these cases were transfused was situated some eight miles from the firing line. The wounded were sent back over very uneven ground, and in bad weather the mud made transportation extremely difficult. In consequence from six to twelve hours (occasionally as much as twenty-four hours) would elapse before the wounded man reached the hospital. An attempt was made to establish an advanced operating station, but this had to be abandoned because of the enemy shell fire. The delay, the pain and the fatigue consequent upon transportation over rough country increased the shock and collapse. Many of these patients were therefore in extremely bad shape when they arrived in the hospital. Rapid pulse and low blood-pressure were characteristic features presented. The immediate effect of transfusion was to raise the blood-pressure and to produce a slow full pulse. This is shown in the records which were kept of the individual cases and indicates a quick response to the therapeutic measure employed, the immediate beneficial effect being maintained in the vast majority of instances.

Many of these cases were desperate from the outset, and it is noteworthy that of 68 cases reported life was saved in 44 instances, *i. e.*, 64.7 per cent.; in other words, the mortality in these cases was 35.3 per cent.; this would appear to be a remarkably good showing. It is worthy of note also that an immediate beneficial result was obtained in 15 of the cases which subsequently succumbed to conditions other than hemorrhage. One is justified in concluding that the transfusion of whole blood practically eliminates the danger of death from hemorrhage *per se*.

Major Edward Archibald has reported 8 cases of transfusion

in hemorrhage; 4 of these were done in three patients for secondary hemorrhage at the base and 4 patients were transfused at the front. Of the latter 2 died of gas gangrene and 2 from profound shock. Of those transfused at the base 2 died of repeated hemorrhages; 1 who was *in extremis* at the time made a remarkable recovery. All of these cases were described by Major Archibald as being "in a very desperate condition, indeed practically moribund" at the time of transfusion.

In May, 1917, Fullerton, Dreyer and Bazett, of the Royal Army Medical Service, reported a series of 15 cases transfused at the British front and in addition 3 cases from other hospital units of the Royal Army Medical Corps. Of these 18 cases there were 8 recoveries. In one instance where the left kidney was wounded by a high explosive shell, secondary hemorrhage occurred thirty days afterward; the kidney was removed and immediate transfusion was performed. The improvement in the patient's condition was described as dramatic and recovery ensued.

The experience which has been already attained in the treatment of the wounded at the front has been ample to prove the immense value of transfusion in cases of hemorrhage, both primary and secondary. We agree with the conclusions of Archibald and Maclean that transfusion of blood is valueless in shock. When, however, shock is accompanied by hemorrhage then transfusion has proved of immense value, and we may conclude that its employment may turn the scale so that life in many instances has been saved when shock plus hemorrhage exists. In fact, we are warranted in assuming that whenever the wounded man has lost large quantities of blood then the replacement of that blood is the ideal therapeutic measure. Such patients when transfused have the element of danger eliminated which exists from loss of blood. They are in a vastly better position to combat shock, sepsis, the ordeal of some necessary and perhaps extensive operation or other condition which may threaten life. In other words, by transfusion we believe we can largely eliminate the danger which exists from hemorrhage and by replacing the lost

blood may materially aid the wounded to combat other conditions which might without transfusion prove fatal. We can by transfusion place the man in the position of one similarly wounded but who has lost no large amount of blood.

We do not propose in this paper to discuss methods to any extent. The citrate method has many advantages and the use of Kimpton's tubes has been found serviceable. The writer has mainly employed a modification of the syringe and cannula method introduced by Lindeman, and in 1 case found the two-way stopcock apparatus of Unger answer admirably. I understand the Americans on the Western front have ingeniously succeeded in keeping blood drawn from the donor in cold storage for forty-eight hours or more in anticipation of an emergency.

The author has had no experience in immunized blood for use in septic cases. This has been termed "vaccination transfusion." The donors are immunized by doses of vaccines prepared from the particular virus before the transfusion is undertaken. Heyd and E. S. Hooker have recently reported successful cases—the former in endocarditis, with a blood culture of Streptococcus viridans, the latter in 4 cases of Staphylococcus septicemia. The possible application of such methods to war surgery is obvious.

The amount of blood transfused has varied. The writer has frequently transfused 1000 c.c. and in 1 case 1140 c.c. from one donor. Robertson mentions 5 cases of the injection of 1200 c.c. In none of these instances has the donor suffered other than very temporary inconvenience. The desirable amount must be determined in the individual case, but in hemorrhage one aims at from 600 to 700 c.c. as a minimum while in the majority of instances of severe hemorrhage it would appear that a larger amount, say 1000 c.c., is more effective.

There are mainly two dangers to be avoided in the transfusion of blood: the transmission of some infective disease and the danger of hemolysis. The donor should be carefully examined for the purpose of excluding syphilis or other communicable diseases. The blood of both donor and recipient should be tested in order to determine their iso-agglutinin characteristics.

As Ottenberg has pointed out, the most severe and possibly fatal reactions occur when the serum of the recipient agglutinates the corpuscles of the donor, but other conditions of incompatibility while unlikely to cause serious disturbance will lessen materially the therapeutic value of transfused blood.

Meleney, Stearns, Fortuine and Ferry, in a study of 280 transfusions, find that the more transfusions a patient is given the more likely he is to have a reaction, especially if the same donor is used a large number of times. These reactions are considered in all probability to be due either to an intravascular hemolysis or to the formation of a toxic product from the partial splitting of a foreign protein. At the front it has been difficult or impossible to secure laboratory facilities for the proper blood tests, and under such circumstances it has been held that one is justified in proceeding without such tests. The cases are desperate and the demand for prompt action is imperative: the danger from hemolysis, while very real, is not so great as to make it unjustifiable to proceed in urgent cases without investigating the characteristics of the blood. Recently the question of the prevention of hemolysis by suitable tests has received a great deal of attention. It has been shown that in human blood two iso-agglutinins and two isohemolysins may be demonstrated. Absence of both iso-agglutinins or the presence of one or both of them in an individual sample of blood permits the classification of human blood in four main groups. Moss utilized such a classification and prepared two standard human sera, each serum containing one of the iso-agglutinins. These sera were used for testing the blood of the donor as well as that of the recipient. When the blood of the donor and that of the recipient showed a similar reaction one would be satisfied that a suitable donor had been secured. These standard sera may be secured and kept for a considerable period. The test may be done by simple methods, as suggested and carried out by Moss, or by a method, based on the same principle, described by Lee. The employment of the two standard sera has become the method of choice at the front and is now very generally in use.

Captain Karsner has recently published a paper on "Transfusion with Tested Bloods." He tested the blood of 1000 soldiers in the base hospital to which he was attached: the percentage of individuals in each of the four blood groups (using the classification of Moss) differed little from the results arrived at by Moss and by Sanford, except that Group 1, in which the sera contain no agglutinins, was only found in 3.1 per cent. of the cases as against 10 per cent. by Sanford and 8 per cent. by Moss. On the other hand, Group 4, in which the corpuscles do not possess suitable receptors and therefore cannot be agglutinated by any serum was found in 46.2 per cent. of the cases as against 47 by Moss and 43 by Sanford. This Group 4 constitutes what has been called the Universal Donor. Karsner suggests that prospective donors might be tested and in cases of emergency in which tests cannot be made, Group 4 only be used so that the most dangerous forms of hemolysis—namely, that in which the corpuscles of the donor are hemolyzed by the serum of the recipient, may be eliminated. That hemolysis is a real danger is shown by the fact that Robertson reported 3 cases out of his series of 68. One of the 10 cases at Salonika and 1 of Archibald's series of 8 developed hemolysis. Archibald's case recovered. The other 4 died. It would not be fair to assume that death was directly due to hemolysis in any of these instances, as the patients were already in a desperate condition from other causes, but in all instances in which hemolysis occurs the effect must necessarily be harmful and the transfusion only tends to hasten the fatal issue.

The writer was a member of the Interallied Surgical Congress which met in November, 1917, at the French Army Medical School, Val-de-Grace, in Paris. It was then determined to investigate the value of the transfusion of blood at the following meeting, the subject to be introduced by Professor Tuffier. Accordingly, at the last meeting of the Congress at Paris in March, 1918, this was done. After full discussion it was concluded that the results obtained by the transfusion of blood justify its being looked upon as the method of choice in the treatment of serious hemorrhage, both primary and secondary. It was agreed that the method of

transfusion employed should make it possible to measure the quantity of blood transfused. Regarding the danger of hemolysis it was concluded that at advanced posts it is justifiable to resort to transfusion even if it be impossible to test the agglutination, as the risk of serious results is relatively small; but it should be tested in all other units.

The surgery of the present war has been remarkable for the progressive developments which have occurred in the treatment of the wounded soldier. Many of our pet theories regarding the treatment of wounds have been ruthlessly upset and effective and revolutionary measures for the saving of life and limb have been evolved, and are today successfully carried out in our hospital corps from the front line to the base. For the first time in war the transfusion of whole blood has been carried out successfully and no treatment has been more spectacular or effective as a life-saving measure in cases of hemorrhage.

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DISCUSSION

Dr. A. J. Ochsner, Chicago:

Some five years ago my colleague, Dr. Nelson M. Percy, became interested in transfusion and made use of the Kimpton tube, which he modified, and since that time we have made many hundreds of transfusions. A number of these were in cases of hemorrhage during ectopic gestation, postpartum hemorrhage and some in cases in which the patient had lost a great amount of blood during operation. This modified method has been fully described, and the point to which I wish particularly to draw attention is the manner of making the Moss grouping. Dr. Percy worked out a plan by which the grouping can be made in a few minutes. Within five minutes from the time the patient is brought into the operating room a sufficient number of donors can be tested and the transfusion carried out at once. By the earlier method it required several hours to make a perfectly reliable test. In a number of transfused cases the patient was taken from a hopeless condition to one in which she had every chance of life. Undoubtedly this is so with these wounded men. With transfusion properly done a man will have the same opportunity of recovery as he would with the same injury without hemorrhage.

Dr. Wallace I. Terry, San Francisco:

A point I want to bring out is that at the University Hospital in San Francisco we have a lot of donors already graded. There are a number of medical students, and some of the nurses and others who are willing to give blood in case of necessity, so that we do not have to take time to test the donors but simply have to test the recipient. It seems to me this plan could be applied in the Army with a company that is going to be kept together; they could easily test out the men according to the Moss grouping and have each man indexed according to his group, so that when a donor is needed they would know at once which man to get.

Dr. Thomas W. Huntington, San Francisco:

I would like to ask the opinion of the Fellows as to the value of transfusing salt solution or one of its analogues as compared with the direct transfusion of blood. The simplicity of such a procedure is so manifest that it seems to me we should not turn down an old and established policy without a careful consideration of the subject.

Dr. Wm. J. Mayo, Rochester, Minn.:

First, as to Dr. Huntington's query as to the relative merits of salt solution and blood transfusion. If salt solution is to be used all the hemorrhage must be stopped and the vessels tied. On at least two occasions I have seen salt solution appear with the blood in an open wound; it had gone straight through. We have usually transfused whole blood up to 600 to 1000 c.c. and then added salt solution if necessary to bring up the tension in the vessels, but the salt solution alone, in my opinion, will not do. If blood is used in spite of the fact that the hemorrhage is not controlled, as may be the case in intra-abdominal injuries, there is a marked tendency to check the bleeding unless it is from a large vessel.

I want to emphasize very strongly indeed what Dr. Terry has said. We have 180 regular donors in Rochester whose blood has been carefully tested. We had the great misfortune once, in a hasty transfusion, to use the blood of a syphilitic, and our patient contracted syphilis. You will remember that one of our Fellows reported such a case in which the same thing happened when a father was being transfused from a son.

Again referring to the paper under discussion, I would say that Class 4 blood is safe for all patients; if we are in a hurry we send for a Class 4 donor. If the citrate method is used the blood may be kept in cold storage for some time and does not hemolize any type of blood. I do not see why Class 4 blood could not be carried forward when the donor himself could not be sent. I see no reason why we could not, with the proper means of control, test the blood of every man going into the line and find out what class he is in, with this knowledge it would be easy to obtain proper blood for him if it were necessary.

I want to remind this Association that it has the privilege of congratulating itself on the fact that it is due to one of our own members, Dr. Crile, of Cleveland, that blood transfusion has been made a practical procedure. Although transfusion was practised as early as 1648, it was not until after Crile's work that the transfusion of whole blood became practicable.

Dr. Edward Martin, Philadelphia:

In laboratory work we find that acacia solution with bicarbonate will raise the blood-pressure in twenty minutes and keep it up for twenty-four hours. This acacia solution has been used at the Front. It has been found that in an acute hemorrhage the patient probably does not die because of loss of blood, but on account of low blood-pressure and deficient circulation.

Dr. Herbert A. Bruce, Toronto, Canada:

I am fortunate in having obtained from Major George W. Crile just before leaving France, a report on 320 transfusions of blood which have been performed by the members of the Surgical Staff of No. 9 (Lakeside, U. S. A.) General Hospital since their arrival in France. Of this number, 268 were done at the Casualty Clearing Stations and 52 at the Base Hospital.

At the Front, the indications are: (1) Hemorrhage; either severe primary or early recurrent. (2) Shock. (3) Shock and Hemorrhage.

The majority of the cases seen at the Front were treated in resuscitation wards and represent all manner and degree of hemorrhage, shock, collapse, and severity of battle casualty, so that pure loss of blood and pure shock were rare and the combination of the two quite the rule.

From a clinical point of view it is very difficult at times to differentiate between these two conditions, since a rapid pulse, a low blood-pressure, and collapse are common to both. In hemorrhage, however, the patient is usually pale, the lips are blanched; he is restless, thirsty and anxious. The shocked patient is the opposite, and a grayish blue color has been found quite constantly. The most reliable means for making a differential diagnosis between the two is by the total white cell count, a marked increase being constant with hemorrhage and absent with shock.

At the Base Hospital, the indications for transfusion are: (1) Hemorrhage: severe recurrent, secondary, or postoperative. (2) Anemia, secondary to more or less prolonged sepsis. The indications for replacing large blood losses are the same here as elsewhere.

Selection of Donors. Other things being equal, three points were considered in the selection of donors. (1) That he be free from *acute infections*, especially active syphilis and tuberculosis. (2) Efforts to avoid *man-power wastage* were made, and with this point in view the donors were selected from the lightly wounded and dental cases. Men with sprained ankles and with deranged semilunar cartilages of the knee-joint were given the preference, as the majority of these are able to march again only after a more or less prolonged convalescence. (3) Experience has shown that the best results are obtained when the donor and recipient are members of the *same blood groups*, although Group 4 blood (Lee's classification) has been transfused into recipients of other groups without untoward reactions except in one case.

Method of Grouping. Grouping was done in 104 instances. This was done in 52 of the 268 cases transfused at the Front. The method of Lee based on the long known interaction of serum and red

blood cells which places every individual in one of four groups was used. All were done with sera of Group 2, and three preserved with 0.5 per cent. carbolic, put up in sealed glass tubes by Captain Karsner. In as much as serum loses its power to agglutinate in time (one month or more), surgical teams are now made up with a known Group 2 and a known Group 3 among the members in order to have a fresh supply for tests when needed.

At the base 14 cases were matched by the method of Kolmer and 38 were grouped by the simpler more rapid method of Lee.

At both casualty clearing stations and at the base no incompatibilities were observed in transfusions in which the donors and the recipients of the same group were used. One unfavorable reaction occurred when a Group 4 (universal donor) was used on a recipient of another group.

Results Where Blood Was Not Matched. Unmatched or ungrouped blood was used in 216 cases, in the majority of instances without any symptom attributable to blood incompatibility, immediate or late. Graham, however, in 51 cases not grouped reported several instances of chilly sensations and slight chills, but no distinct rigors. In no case was there hemolysis following the transfusion, although the urines were not examined for hemoglobin. In one case there was a severe reaction resulting in death in a few hours.

Shupe in 47 cases observed one case with sharp reaction during transfusion. The transfusion was stopped after the patient had received 300 c.c. of blood, and no jaundice or hemoglobin followed. This patient recovered and left the casualty clearing station in a week. No hematuria was noted in any case.

Harrison in 50 cases had only one slight reaction, that in a case transfused for severed popliteal artery.

Karsner had already reported "two instances at the base in which reactions were noted in the recipients, one being due to confusion of names of donors, whereby the donor's corpuscles were agglutinated by the recipient's serum, the other being a case in which the recipient's cells were agglutinated by the donor's serum. In both cases the reaction appeared after the introduction of about 50 c.c. of the donor's blood and the operation was immediately stopped. In neither case was the reaction fatal."

Methods of Transfusion. Paraffin-lined tubes were used in most of the cases; the syringe (Lindeman) method in 2 cases; in 2 cases, owing to absence of proper apparatus at the casualty clearing station, the blood was collected into an equal volume of 2.5 per cent. saline and was given as an ordinary intravenous, with good results.

From 250 to 1250 c.c. of blood were used, depending mainly on the donor. There is a tendency to give too much blood.

Results. 1. In primary anemia due to hemorrhage when sepsis was either absent or trifling, striking and permanent, beneficial results were noted.

2. In mixed hemorrhage and shock, such as are found among the desperate multiple wound cases in the resuscitation wards, blood transfusion proved to be of value both before and after operation in a certain number of cases. In the main, patients suffering from hemorrhage and deep shock and who had extensive wounds, anatomically beyond repair or recovery, did not improve with transfusion.

3. Eight cases of sepsis and anemia were transfused in which the anemia appeared to be the main factor. These cases were improved immediately in their mental and general condition. In several of these cases the pulse would remain slower and sustained for days and weeks. Six cases were transfused more than once with improvement noted each time. When the sepsis was the prominent feature only temporary assistance was obtained by transfusion.

Dr. Alexis V. Moschcowitz, New York City:

I only wish to emphasize the great value of the Lewisohn method of transfusion by means of citrated blood. The superior advantages of this method are threefold; first, its extreme simplicity, no complicated apparatus being necessary beyond two simple cannulæ; second, that, if necessary, citrated blood can be kept for a considerable period in cold storage; and third, that it is just as good as whole blood.

Dr. John Bapst Blake, Boston:

Kimpton, who developed the Kimpton tube, is on my service at the Boston City Hospital. No matter how carefully he studies the cases he occasionally gets hemolysis. His cases number between 400 and 500; he has had 3 cases in which the grouping showed the donor's blood to be safe, but the transfusion was followed by hemolysis and by death in one instance. This fact, that the present method of grouping blood may occasionally be untrustworthy, explains those rare fatal cases in which the utmost care and caution have been used. This error should be eliminated by further study.

Another point worth considering is whether smaller quantities of blood, say 400 or 500 c.c., may not be as effective as 1000 or 1200 c.c.

Dr. Alexander Primrose, Toronto (in closing):

Several points brought out in discussion are included in my paper though not read. As to the relative merits of normal salt solution

spoken of by Dr. Huntington, and with regard to the citrate method discussed by Dr. Moschcowitz, my point is this: if you can transfuse blood absolutely unaltered, and at the same time have good reason to believe that the blood lives and functionates, then the transfusion of whole blood is the ideal method. There is no question that normal salt solution will save life in many instances, but it maintains the blood-pressure for only a limited time. We have proved again and again that when normal salt solution has produced temporary improvement it is often necessary to transfuse whole blood subsequently if life is to be saved. Whole blood means blood which is not contaminated by any foreign element. The method which we used was the cannula method suggested by Lindeman, with slight modification, and this was used extensively. I believe that the citrate of sodium is the least harmful of materials suggested to prevent coagulation, and when it is difficult to get cannulæ and syringes at the Front, the citrate method is bound to become the one of choice, but in hospital practice and at base hospitals, the syringe-cannula method is ideal. As to the ingenious method of keeping blood in cold storage, I have referred to that in my paper. For the purpose of testing blood the two standard sera, as suggested by Moss, are now accepted. They can be produced and used for testing without difficulty.

In conclusion, I may say that no one can talk of blood transfusion without paying a tribute to the work of Crile. It was he who first stimulated activities which led to the wide adoption of transfusion. The direct cannula method of Crile gave us the opportunity for testing out its value, later on the indirect method where the amount can be measured proved more satisfactory and is now regarded as the method of choice.

LENGTHENING OF THE TENDO ACHILLIS IN THE TREATMENT OF COMPLICATED POTT'S FRACTURE

By CHARLES N. DOWD, M.D., Major, M. C.
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Without doubt, the ordinary results from the treatment of Pott's fracture are reasonably good. Occasionally, however, one sees a patient who emerges from his primary treatment with distressing disability. The backward and outward displacement of the tarsus, the separation of the malleoli, and the eversion of the foot, one or all, produce very disturbing loss of function.

Recently, soon after the study of two such cases, the writer was surprised at his inability to maintain correct reposition of the fragments in what seemed to be an ordinary Pott's fracture. The patient, a man aged forty years, received his treatment, under anesthesia, only four hours after falling and sustaining a Pott's fracture (Roosevelt Hospital, History A 9649, December 28, 1917). Reduction of the deformity was easy, although there was much swelling, and extreme dorsal flexion was not practicable. The tarsus was pushed well forward and the foot slightly inverted and held at an angle of 90 degrees with the leg. A firmly fitting plaster-of-Paris dressing was then applied.

The next day an *x*-ray picture showed that the reposition had not been maintained, but that the tarsus was displaced backward. It also showed a longitudinal split in the lower end of the tibia with wide separation of the fragments (Fig. 1).

This longitudinal split in the lower end of the tibia is not mentioned in the ordinary treatises on Pott's fracture, but its

existence in this and in the following case show that it is one of the conditions which must be borne in mind. It explains the difficulty in maintaining apposition. The articular surface of the tibia was so shattered that it presented no satisfactory obstacle to the upward and backward displacement of the tarsus under the pull of the calf muscles.

FIG. 1.—Comminuted Pott's fracture, showing posterior displacement of tarsus after deformity had been reduced under anesthesia and after a firm plaster-of-Paris dressing had been applied.

On January 1, anesthesia was again given in the expectation of lengthening the tendo Achillis. However, correct position was easily obtained, and, since the swelling had subsided it was believed possible to maintain the corrected position by plaster, hence a closely fitting plaster dressing was again applied and the tendon was not then cut.

This was an error. On the following day the *x*-ray showed the position worse than ever (Fig. 2). It was manifestly necessary

to remove the displacing factor—the pull of the calf muscles. The writer had recently seen the deformity of Pott's fracture reproduced under the tension of the calf muscles while a patient was struggling in the early stages of anesthesia. When he was quiet the foot was easily put in correct position, but when he struggled the tension of the calf muscles reproduced the deformity in spite of strong efforts to prevent their doing so. It was a vivid

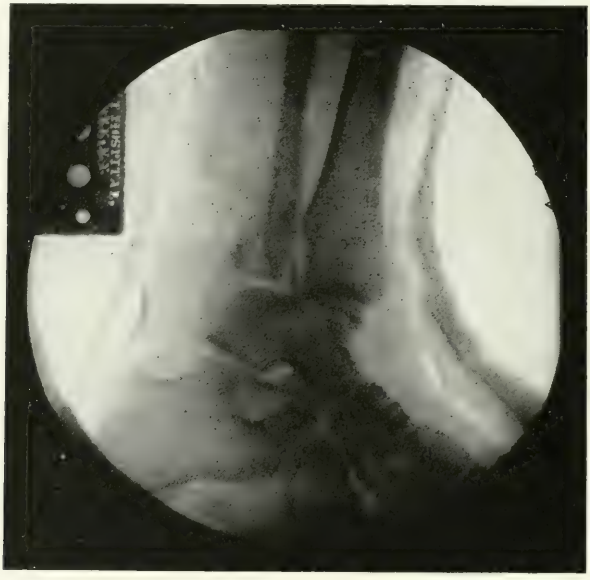

FIG. 2.—Comminuted Pott's fracture, showing posterior displacement of tarsus after second attempt at reduction under anesthesia and application of plaster.

demonstration of the action of these muscles in producing this deformity.

The tendon was, therefore, lengthened by the method of Hibbs, and molded plaster splints were applied. Dr. James M. Hitzrot, who was present in consultation, approved the procedure after endeavoring to maintain the position with the knee flexed.

The later notes are as follows: Patient left the hospital Janu-

ary 24, with foot in excellent position, as shown by inspection and by *x*-ray (Figs. 3 and 4). He walked with crutches, foot in plaster; weight bearing forbidden.

February 15. Plaster removed. Position of foot and ankle excellent. Still unable to plantar flex foot. Slight weight bearing allowed.

FIG. 3.—Improved position of tarsus after lengthening the tendo Achillis and reapplication of plaster.

February 21. Calf muscles beginning to work satisfactorily. Tendon shows good formation. Position of foot good. Slight swelling present.

March 4. Good position of foot and ankle. Bears weight on foot. Calf muscles contracting well. Ankle motion 80 to 100 degrees.

He improved steadily, resumed his business early in March, using crutches. On June 3, motion in ankle was 80 to 105 degrees. Tendo Achillis strong. Calf muscles somewhat atrophied but contracting well and gaining strength steadily. Walks much. Still slight limp. Does not use crutches. The position of foot is

excellent. The malleoli seem normal and are the normal distance apart.

A second similar case was seen January 9, 1918 (Roosevelt Hospital, History A 9706). A traffic policeman of very strong build, who fell on the ice and sustained a Pott's fracture. The *x*-ray showed a longitudinal splitting of the lower end of the tibia

FIG. 4.—Posterior view taken at same time as Fig. 3.

(Fig. 5) and his calf muscles were particularly strong, hence the tendo Achillis was lengthened at the time of the first anesthesia and molded plaster applied. The corrected position was maintained as shown by inspection and by *x*-ray plates (Figs. 7 and 8). The progress corresponded to the progress of the first case in all essential details. He was put on limited police duty in two and one-half months and gained steadily in strength and in function.

He was seen on May 27. Walked with a very slight limp. Motion in foot 75 to 110 degrees. Tendo Achillis very strong and well developed. Calf muscles contracting satisfactorily.

FIG. 5.—Comminuted Pott's fracture held in good position after lengthening of tendo Achillis and application of plaster.

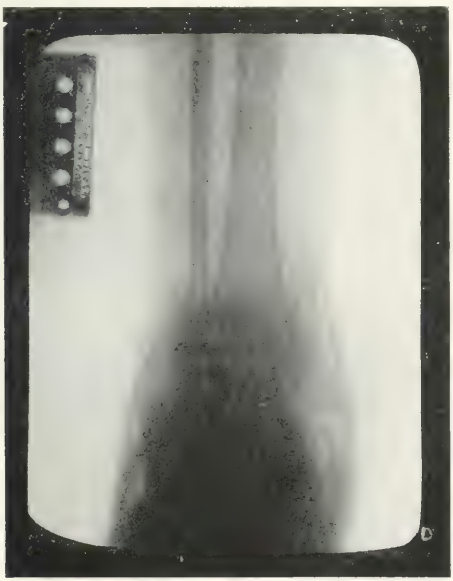

FIG. 6.—Posterior view of Fig. 5.

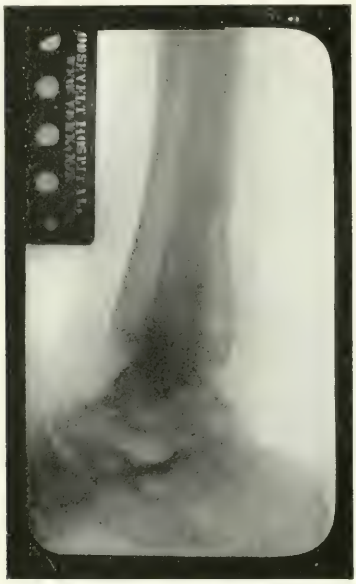

FIG. 7.—Same case as Figs. 5 and 6, four months later

FIG. 8.—Same case as Figs. 5, 6 and 7, four months later (posterior view).

Conformation of ankle-joint and position of malleoli and of foot seem normal. Firm on his feet and expects to resume his regular duties as traffic policeman before the summer is past.

Hibbs[1] has had large experience in the lengthening of the tendo Achillis for "muscle-bound feet." He assures a return to normal muscle function in adults in four to six months "with absolutely no danger of any impairment of the strength of the tendon or the function of the muscle."

I do not find that the procedure has been much used in the treatment of Pott's fracture, but Robert Jones[2] advocates tenotomy of the tendo Achillis in those instances where the tarsus is displaced forward and in the equinus deformity which sometimes follows badly healed Pott's fractures.

Guichard[3] favorably records the treatment of four cases of Pott's fracture by the aid of tenotomy in 1902.

Manifestly, the procedure is not to be advocated in those instances where proper position of the fragments can be maintained without it, but it certainly should be used in those instances where such position cannot be maintained, especially if there is a longitudinal transverse split of the lower end of the tibia. Also, *x*-ray pictures should be repeatedly taken to ascertain whether plaster maintains the position and whether a longitudinal split exists.

In military surgery the frequent transfer of patients from one surgeon or hospital to another, and the fact that so many soldiers are strong and muscular, lead one to be particularly careful that bad position is not accepted when good position can so easily be secured by so simple a procedure.

The period of treatment does not differ, materially, from the four and two-tenths months, which Dr. Estes stated yesterday as the term to be expected after fractures of the lower part of the leg. It is also to be remembered that the molded plaster splints of Stimson give more security than a circular plaster encasement.

[1] New York Med. Jour., July 19, 1902; ibid., May 2, 1903; ibid, October 24, 1914; Annals of Surgery, 1906, xliii, 280.

[2] Injuries to Joints, p. 174, London, 1917. Notes on Pott's Fracture, Liverpool Medico-Chirurgical Journal, 1887, p. 265.

[3] Thèse de Paris, 1902, De la Tenotomie du Tendon d'Achille dans les Fractures de Jambes.

ANATOMICAL METHODS OF APPROACH IN THE SURGICAL AFFECTIONS OF THE LONG BONES.

By JAMES E. THOMPSON, M.D.
GALVESTON, TEXAS

To ensure absolute safety in the performance of surgical operations four requisites are necessary in the operator: (1) sound anatomical knowledge; (2) accurate pathological training; (3) technical skill; (4) well-balanced judgment. Each is so important in its particular way and all are so interdependent that the loss of one of them will lessen the value of the others. For a number of years past it has been a matter of observation that many surgeons were showing a tendency to drift away from the traditions of the old school as to the necessity of a profound anatomical training as a stepping-stone to the career of a surgeon. The repeated assertion that "a good anatomist was often a timid surgeon" came to have a meaning that the timidity was a direct result of the anatomical training, which we must admit is a very fallacious conclusion to draw. Observation will support the statement that the men who have left the greatest impress on scientific surgery have achieved it by contributions to anatomical improvements in technic and by additions to our knowledge of surgical pathology. And of these two the former is by no means the least important. Witness the development of the modern operations for supravaginal hysterectomy and the Wertheim operation for cancer of the uterus and compare them with the crude procedures in vogue thirty or more years ago. In every direction we are paying more attention to anatomical details, the aim of

the surgeon being to complete the operation with the least possible hurt to the surrounding structures. Some operations, such as those for the radical cure of hernia, for the removal of cervical glands and the complete breast operation, are models and triumphs of clean dissection.

In visiting the important clinics of the country one cannot help being impressed by the fact that wonderfully good surgery is performed on the abdominal viscera, and in some places an unusual degree of skill is shown in neck operations. On the other hand, with a few exceptions, the work done on the arms and legs is not of the highest order. This deplorable condition is the result partly of want of practice and partly of deficient anatomical knowledge. During an experience of over a quarter of a century of teaching operative surgery on the cadaver to successive generations of senior students I have clung tenaciously to the old traditions of insisting on a thorough course in the surgical anatomy of the typical operations, such as ligature of arteries and exposure of nerves and tendons, before allowing the students to indulge in the atypical operations in the abdomen and elsewhere. The course has assumed the importance of an advanced course in surgical anatomy of the extremities and head and neck. As a repetition of work previously touched on in the Junior year it has caused a little resentment as being superfluous. I have felt, however, that I was putting the finishing touches to an excellent anatomical training and that I could conscientiously sign my name to the diploma and certify that the recipient was reasonably safe to practise surgery. The expressions of gratitude that reach me constantly from my old pupils as to the benefit of this training have convinced me that the course has been a wise one, and consequently it is still followed.

During this period I have had constant opportunity of studying anatomical regions from the point of view of contemporary surgical procedures and of modifying my views as to the best way of exposing the bones and other structures. One important fact was early impressed upon me—namely, that pure anatomical facts which have apparently little surgical significance today may

become of great importance tomorrow; the moral of which is that one cannot store one's mind too compactly with anatomical truths.

During the last few years I have interested myself with the long bones and the best routes by which they can be reached, and the following communication is the result of my studies.

The following conditions may call for operations on the long bones:

1. Fractures in all phases, open or closed; recent or of old standing; ununited or united with deformity.

2. Osteomyelitis, acute or chronic.

3. Deformities: such as occur in rickets, bow-legs, knock-knee, etc.

4. In orthopedic surgery: to attach silk ligaments or fascial strips to alleviate paralytic forms of talipes.

5. Tumors: such as chondroma, osteoma, cysts, sarcomata.

Some of these affections, such as osteomyelitis and some of the tumors, have a predilection for the neighborhood of the epiphyseal lines and epiphyses, a fact which makes it necessary for us to be familiarly acquainted with the relationship of the epiphyseal lines to the joint cavities and the lines of reflexion of the synovial membranes. For example, the epiphyseal line of the proximal end of the femur lies entirely within the joint, the line of reflexion of the capsule being far distal to it in front and behind, a condition of affairs which is responsible for the frequency with which the hip-joint becomes secondarily infected in chronic osteomyelitis of the head of the femur. Further, the proximal end of the shaft which is represented by the neck of the femur in contact with the epiphyseal line is occasionally affected with acute osteomyelitis. This also lies inside the capsule and the diseased focus may point directly into the joint cavity and not burrow, as it often does, along the shaft below the line of attachment of the capsule. The epiphyseal line of the upper end of the humerus is within the capsule on its medial, but outside it on its lateral aspect. As a rule, foci of acute osteomyelitis point outside the other large articulations.

In exposing the long bones the following principles must be scrupulously observed:

1. Easy Access to the Site of Fracture or Focus of Disease. So far as possible we should try and avoid deep wounds where shallow ones will suffice, but if anatomical structures are less damaged by employing deeper dissections, preference must be given to the latter.

2. Preservation of all Nerves both Sensory and Motor. It might seem a superfluous refinement to allow a cutaneous nerve to influence us in the choice of an incision, but whenever possible even cutaneous nerves should be preserved. Thus patients will often complain bitterly of numbness after complete division of cutaneous nerves, especially those supplying the hands and feet. Partial division of a cutaneous nerve is often followed by neuralgic symptoms of an intractable nature. The preservation of the motor nerves is a vital necessity. Upon this, more than on any other factor, does the future usefulness of the limb depend.

3. Prevention of Unnecessary Injury to Muscles. So far as possible the approach should be between the muscles. In some instances, however, the muscles may be split parallel to their fibers without doing any permanent damage. As an example, the lower portion of the triceps brachii may be split for a considerable distance above its insertion without serious damage to its function. In situations where the fractured ends of the bones are covered by a transverse muscle, as in the upper end of the radius (supinator), an attempt should be made to peel the muscle from the bone and retract it upward or downward rather than to divide it. If it is necessary to divide a muscle the line of the incision should be made so far as possible from the point where its nerve supply enters it.

4. The Preservation of the Vascular Supply. It is always wise, other things being equal, to choose a route remote from the bloodvessels. When this is impossible they should be protected with the greatest care. To deprive a muscle or a group of muscles of their proper amount of blood will retard both the

healing processes and their ultimate return of function on which the future of the limb depends.

Further, it must be borne in mind that any injury of the nutrient arteries of the bones must be avoided. This will entail careful consideration as to their origin from the main trunks and the situations where they enter the bone. Extensive denudation of the fractured ends of the bone should be avoided for the same reason.

The Upper Extremity

The Radius. 1. *Distal Extremity.* This consists of the lower epiphysis and the contiguous part of the diaphysis. The epiphyseal line is entirely outside the articulation. The posterior surface of this extremity is occupied by grooves for the extensor tendons of the fingers, thumb and wrist (Fig. 1).

The *anterior surface* is covered deeply by the pronator quadratus muscle and the tendinous insertion of the brachioradialis, also by the radial artery and the superficial and deep flexor muscles. The medial surface is opposed to the ulna with which it articulates. The *lateral surface* is prolonged into the styloid process, on which is found a groove which is occupied by the tendons of the abductor pollicis longus and the extensor pollicis brevis. Into the proximal parts of the anterior and posterior lips of the groove and to its floor the tendon of the brachioradialis is inserted. This surface is the only really accessible part of the lower end of the radius and it can be exposed by an incision carried vertically upward from the anterior margin of the styloid process. The tendon of the brachioradialis will be exposed, having medial to it the radial artery. If the artery be retracted the pronator quadratus will be seen. The radius will be exposed between the brachioradialis insertion and the pronator quadratus (Figs. 2 and 4). This will enable the lower epiphysis and the neighborhood of the epiphyseal line to be reached with ease and safety, and also is an accessible route for osteotomies in some cases of badly set Colles' fractures.

The higher parts of the lateral aspect of the distal end of the

radius can be more easily reached by a deep dissection between the brachioradialis anteriorly and the extensor carpi radialis longus

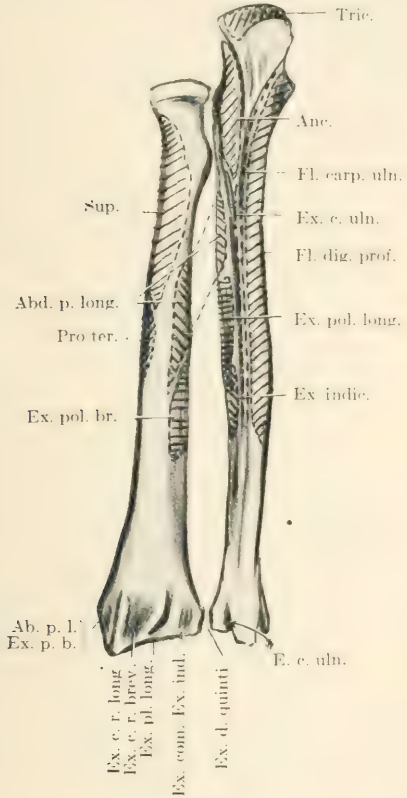

FIG. 1.—Posterior view of radius and ulna, showing origins and insertions of muscles. The abbreviations in this and all subsequent figures refer to the new anatomical nomenclature followed by Cunningham. In the picture of the ulna it will be seen that a part of the shaft medial to the posterior subcutaneous ridge is shown, with the origins of the flexor carpi ulnaris and the flexor digitorum profundus. For all the plates I am indebted to Prof. William Keiller. Most are modifications of the excellent plates in Cunningham's Anatomy. A few are from Spalteholtz. Some are from original dissections. The sections of the joints are from Beesly and Johnston.

posteriorly. In fact, the lateral aspect of the lower third of the radius can be safely exposed by this route. The following are the

steps of the dissection (Fig. 3): expose the tendon of the brachioradialis and retract it anteriorly. The tendon of the extensor carpi radialis longus comes into view, passing vertically downward. This is crossed obliquely just above the base of the styloid process by the abductor pollicis longus muscle and below this by the extensor pollicis brevis. Retract the extensor carpi radialis

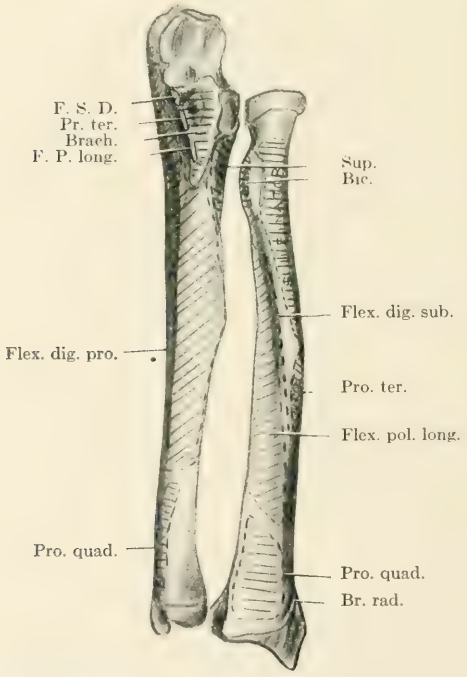

FIG. 2.—Anterior view of the radius and ulna.

longus medially and the abductor pollicis longus distally. This will expose the lateral aspect of the radius as far as the groove in the styloid process. If more exposure is needed the tendon of the brachioradialis can be peeled from the bone and reattached after the operation is completed. By this procedure a larger area of bone can be exposed, but it perhaps imperils the tendinous groove in the styloid process (Fig. 1).

The posterior surface is covered by the dorsal carpal ligament and is grooved by the following tendons in order from the medial to the lateral side: the extensor digitorum communis, the extensor indicis proprius, the extensor pollicis longus, the extensor carpi radialis brevis and the extensor carpi radialis longus (Fig. 1).

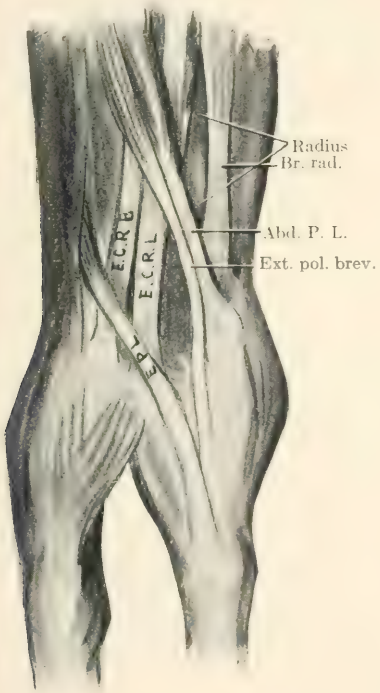

FIG. 3.—Posterolateral view of a dissection of the lower part of the forearm just above the wrist. A considerable area of radius can be seen in the interval between the brachioradialis and the extensor carpi radialis longus. This area is bounded below by the abductor pollicis longus. (Original dissection.)

Superficial to these we find the dorsal carpal ligament binding the tendons down in their grooves. Above the upper edge of the dorsal carpal ligament there is a small area of the lower end of the radius that could be exposed by a careful dissection carried along the lateral border of the extensor digitorum communis ten-

don. The deep dissection after medial retraction of the digitorum communis would expose the extensor pollicis longus, passing downward and laterally under the dorsal carpal ligament. Just above the upper border of the dorsal carpal ligament a triangle

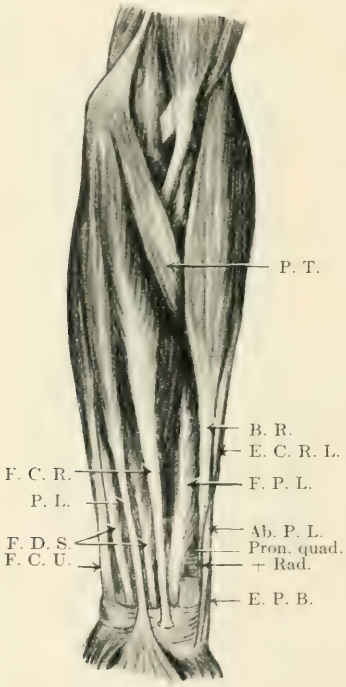

FIG. 4.—Dissection of the muscles on the anterior aspect of the forearm and wrist. The arrow marked +Rad. points to the medial side of the brachioradialis tendon and its point shows an interval between the brachioradialis and the pronator quadratus. By retracting the brachioradialis laterally and peeling the pronator quadratus medially from the surface of the bone a considerable area of the anterior surface of the radius can be exposed.

can be made out, the base of which is formed by the upper border of the carpal ligament, the lateral side by the extensor pollicis brevis and the medial side by the extensor pollicis longus (Fig. 5). In the floor of this triangle a part of the posterior surface of the radius and the tendon of the extensor carpi radialis brevis can be seen.

The area of bone exposed is very small, but can be enlarged by retraction of the short and long extensors of the thumb (Fig. 6). It would hardly be wise to choose this route as a deliberate method of exposure except in rare circumstances, because it would expose the extensor tendon sheaths to the risk of damage and possible infection. Even in the cadaver it is a difficult matter to dissect this space without opening some of the synovial sheaths. The surface of the radius beneath the dorsal carpal ligament is grooved by the extensor tendons and is, surgically speaking, inaccessible.

2. *The Shaft. Anterior Surface.* The proximal end of the anterior surface of the shaft is very deeply situated, being covered by the brachioradialis muscle and the muscular masses attached to its surface. The distal end is nearer the surface. The base and anterior edge of the styloid process are subcutaneous. The whole of this surface from the neck proximally almost as far as the articular margin distally is covered by the following structures in order (Fig. 2): biceps tendon (insertion), supinator (insertion), flexor digitorum sublimis (origin), pronator radii teres (insertion), flexor longus pollicis (origin) and pronator quadratus (insertion). The radial artery with its venæ comites lies on all of these structures, and at the distal border of the pronator quadratus the artery lies on bone. The brachioradialis muscle is superficial to the radial artery in the proximal third of the forearm, but gradually passes to the lateral side to reach its insertion. Superficial to the pronator quadratus muscle we find the tendons of the flexor carpi radialis, flexor pollicis longus and the lateral tendons of the flexnor digitorum sublimis (Fig. 4). It is evident that the *proximal third* of the anterior surface is inaccessible, owing to its great depth and anterior relations. The *middle third* is also quite deep but could with a little difficulty be exposed by the following dissection. Incision of the deep fascia along the medial border of the brachioradialis and retraction of that muscle to the lateral side of the forearm would expose the insertion of the pronator radii teres and the radial origin of the flexor digitorum sublimis. By dissecting between these two muscles, and if necessary peeling the sublimis medially from its insertion and the

underlying flexor pollicis longus along with it, the surface of bone would be laid bare (Fig. 2). In the *lower third* a considerable area of bone could be exposed safely by dissecting to the medial side of the brachioradialis tendon. A strip of bone reaching from the insertion of the pronator radii teres to the base of the radial styloid process, lying lateral to the origin of the flexor pollicis longus and the insertion of the pronator quadratus, would be accessible (Figs. 2 and 4). The lower part of this area has already been described in the section dealing with the surgery of the distal end of the bone.

Posterior Surface. This surface in its proximal half is not so deeply embedded in muscle as the anterior surface. A study of Fig. 1 will show the muscles attached to it. The insertion of the supinator muscle occupies nearly all the proximal third. Distal to this, in order, we find the origins of the abductor pollicis longus and the extensor pollicis brevis arising from a strip on the medial half of the bone. Opposite the origin of the abductor pollicis longus we find the insertion of the pronator radii teres into the lateral margin of the shaft along a narrow roughened ridge. The part of the shaft below the insertion of the pronator radii teres, to which no muscles are attached, is covered by the fleshy bellies of the abductor pollicis longus and extensor pollicis brevis on their way to the groove on the outer aspect of the styloid process. Between the origin of the abductor pollicis longus and the insertion of the pronator radii teres a narrow strip of bone is seen to which no muscle is attached. This is continuous with the large bare area below. This narrow strip of bone and a considerable area of the bare surface below it can be exposed by the following procedure: The lateral border of the extensor digitorum communis tendon is exposed, at a point corresponding to the junction of the middle and lower third of the forearm, by an incision which follows a line from a point corresponding to the middle of the posterior aspect of the wrist to a point about a finger's breadth anterior to the external epicondyle of the humerus (Fig. 5). If this tendon is followed upward it is easy to separate it from the tendon of the extensor carpi radialis brevis. The

common extensor of the fingers is retracted medially and the short radial extensor laterally. The abductor pollicis longus is then fully exposed and on the lateral border of the radius the insertion of the pronator radii teres is seen. By retracting the abductor

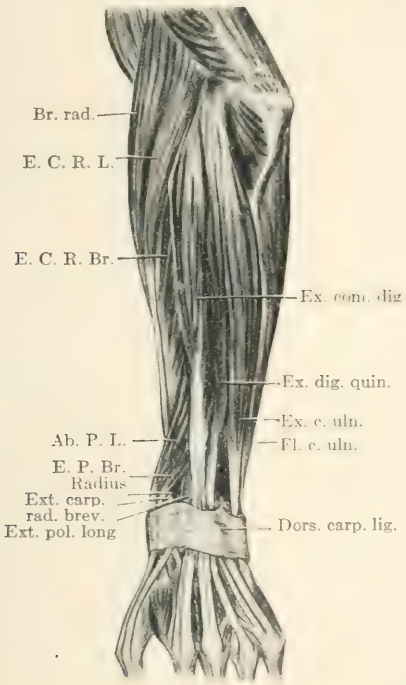

FIG. 5.—Dissection of the muscles of the posterior aspect of the forearm and wrist. Above the dorsal carpal ligament a portion of the lower end of the radius can be seen lying in an irregular quadrilateral area bounded by the extensor pollicis longus medially, the upper edge of the dorsal carpal ligament distally, the extensor carpi radialis brevis laterally and the extensor pollicis brevis proximally. In the upper part of the arm the aponeurotic interval between the extensor digitorum communis and the extensores carpi radialis brevis and longus is shown by an accentuated white line.

pollicis longus distally and medially a considerable area of the posterior surface of the radius can be exposed (Fig. 7). If necessary this muscle can be peeled from the bone toward the interosseous membrane. A study of Figs. 5, 6 and 7 will simplify

the understanding of the text. By following the line of separation between the extensor digitorum communis and the extensor carpi

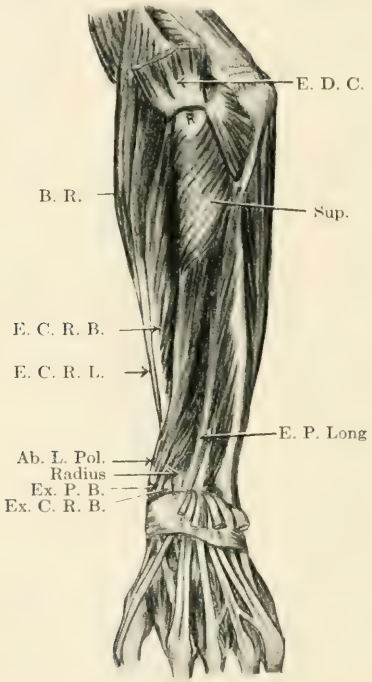

FIG. 6.—Deeper dissection of the muscles on the posterior surface of the forearm. The extensor digitorum communis has been removed and its origin proximally (*E. D. C.*) thrown upward, exposing the head of the radius (*R*) covered by the annular ligament. The distal end of the muscle is thrown over the dorsal carpal ligament. A clear view is shown of the surface of the radius shown in Fig. 5. The whole extent of origin of the abductor pollicis longus is exposed and proximal to this the posterior surface of the supinator muscle as high as the neck of the radius. By retracting the contiguous margins of the abductor pollicis longus and the extensor carpi radialis brevis from one another a considerable area of the bone can be exposed. This is shown in Fig. 7.

radialis brevis and longus as far up as the lateral epicondyle of the humerus (Fig. 5) and retracting the extensor muscle medially the supinator muscle will come into view as high as the neck of

the radius (Fig. 6). In this way all the muscles arising from the posterior surface of the radius can be exposed. By detaching the origin of the common extensor from the external epicondyle this

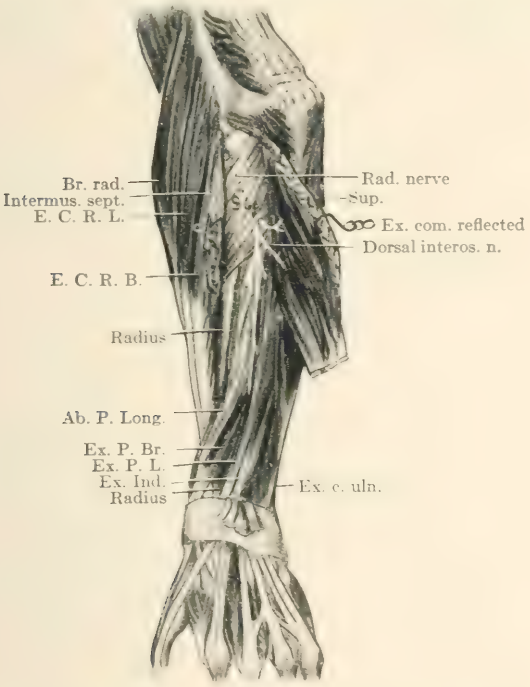

FIG. 7.—A dissection of the muscles of the posterior surface of the forearm showing (1) an area of radius exposed above the upper edge of the dorsal carpal ligament, (2) a large area of the shaft of the radius exposed below the supinator muscle, by separating the abductor pollicis longus and the extensor carpi radialis brevis from one another, (3) the course of the radial nerve through the muscular fibers of the supinator (shown by an oblique dotted line), and (4) the exit of the dorsal interosseous nerve from the supinator muscle and the distribution of the muscular branches to the extensor digitorum communis, abductor pollicis longus and the extensor pollicis brevis.

muscle can be retracted still further medially just as far as the bloodvessels and nerves, which enter it at the level of the lower border of the supinator will endure the traction. By this maneuver the annular ligament of the radius comes into view

and distal to this a more extended view of the supinator muscle (Fig. 7). The incision from end to end will pass along an area free from bloodvessels of any size and will not imperil the nerve supply of any of the muscles brought into view. By means of this dissection a little more than the proximal half of the shaft becomes accessible for surgical procedures if care is taken in exposing the bone covered by the supinator muscle.

It will be convenient here to describe the nerve supply to the muscles concerned and show how we can avoid injuring them. The radial nerve (O. T., musculospiral) gives off muscular branches to the brachioradialis and to the extensor carpi radialis longus near their origins, as it lies between them and the brachialis muscle in front of the lower end of the humerus. In the hollow of the elbow it divides into two branches—namely, the superficial ramus (O. T., radial nerve), which is entirely cutaneous in its distribution and the deep ramus (O. T., posterior interosseous nerve), which is entirely muscular.

The superficial ramus passes down the forearm deeply placed under cover of the brachioradialis muscle. It is placed to the lateral side of the radial artery. In the distal third of the forearm it passes backward under the brachioradialis and pierces the deep fascia to become subcutaneous. It may be injured in operations on the lower third of the lateral aspect of the shaft.

The deep ramus passes distally and posteriorly. It gives off immediately branches to the extensor carpi radialis brevis and to the supinator. It then penetrates the substance of the supinator on its lateral aspect, just below the level of the head of the radius, and lies embedded in the muscular fibers almost as far as its lower border, where it emerges under cover of the extensor digitorum communis, to which it gives branches at once (Fig. 7). Then it passes distally under the name of the posterior interosseous nerve, superficial to the abductor longus pollicis and the extensor brevis pollicis, to which it gives branches which penetrate the muscles on their superficial aspects; it then passes deeply under cover of the extensor longus pollicis and the extensor indicis proprius, to which it gives branches which penetrate them

on their deep aspects. It ends on the back of the carpus under the extensor tendons in a gangliform enlargement.

A study of Fig. 7 will show the arrangement of the nerves. It will be seen that separation of the supinator and the abductor longus pollicis can be carried to a high point if care is taken of the dorsal interosseous nerve. As a matter of fact, retraction of the extensor communis digitorum is resisted opposite the lower border of the supinator, because both the nerves and arteries enter the muscle at this point. This is the danger zone. Starting from here one can follow the course of the radial nerve, both proximally and distally. The distal portion of the dorsal interosseous is quite slender and is bound down to the posterior surface of the deep muscles by a fairly strong band of fascia which it is unwise to attempt to disturb. The proximal portion courses through the supinator very obliquely. It lies about 2 cm. below the joint line on the lateral aspect of the radius and about 5 cm. below the line on its posterior aspect.

In actual operative work on the area of bone covered by the supinator the muscular fibers are usually divided until the radial nerve comes into view, when it is carefully retracted. It would be a better plan to peel the muscle from the bone and retract it either proximally or distally. We have proved the feasibility of this both in the dissecting room and at the operating table. One should avoid pulling on the nerve too vigorously. In one of our cases the extensor muscles were temporarily paralyzed after a bone-plating operation in this region.

3. *Proximal Extremity* (*Head and Neck*). The upper epiphysis of the radius is entirely within the synovial cavity of the elbow-joint (Fig. 8). The head of the bone is firmly grasped by the annular ligament which holds it firmly in the radial notch of the ulna. The ligament also encircles the proximal part of the neck of the bone. The anterior surface of the head and neck is so deeply placed as to be inaccessible. Posteriorly the head can be palpated easily and its rotation felt when the forearm is pronated and supinated. On this surface the supinator muscle passes almost as high as the margin of the head. Covering both head and

neck and supinator muscle is the aponeurosis of origin of the extensor digitorum communis. This part of the bone can be exposed by a vertical incision carried distally from the lateral

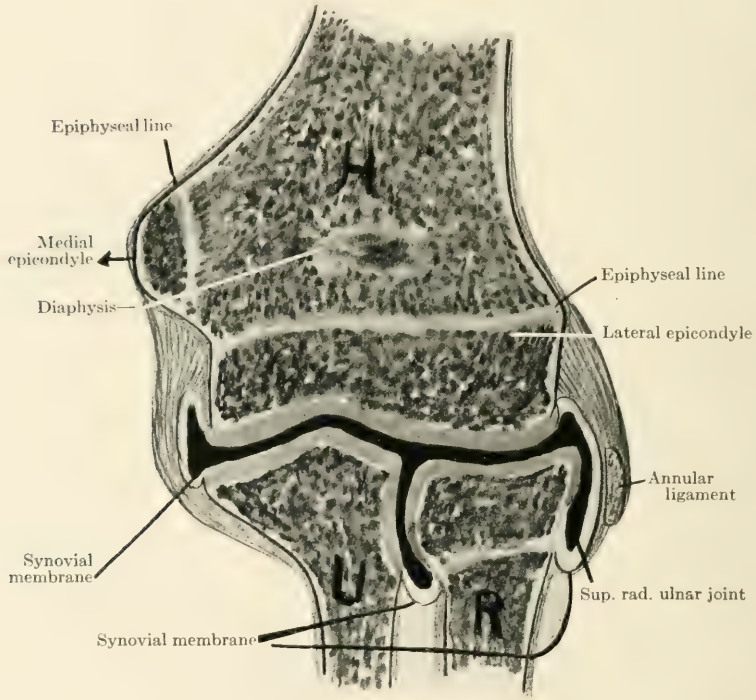

FIG. 8.—Represents a coronal section of the elbow-joint. The downward growth of the shaft between the medial epicondyle and the trochlear surface is well depicted. The lateral epicondyle is below the epiphyseal line and belongs to the epiphysis. The medial epicondyle does not belong to the epiphysis. It will be seen that the lateral epicondyle is the key to the situation in operations for fixation of epiphysis. The shaft above the epicondyle is accessible on either side along the supracondylar ridge of bone.

epicondyle for a short distance. By splitting the attachment of the extensor digitorum communis the annular ligament of the radius and supinator muscle are exposed. After cutting the annular ligament the head comes into view. If a view of the neck

and the contiguous part of the shaft is required the fibers of the supinator are detached and retracted distally or divided. The position of the deep branch of the radial nerve must be remembered.

Summary of Conclusions. *The Distal End of the Radius is Accessible:* 1. In front of the base of the styloid process by passing between the brachioradialis insertion and the radial artery and exposing the bone to the lateral aspect of the pronator quadratus (for Colles's fracture and osteomyelitis of the epiphysis).

2. Above the base of the styloid process by passing between the tendon of the brachioradialis and the extensor carpi radialis longus. At least the lower third of the lateral aspect of the bone can be explored if this incision be prolonged upward (for Colles's fracture and osteomyelitis of the diaphysis).

3. Over a small area of the posterior surface just above the dorsal carpal ligament between the extensor pollicis longus and extensor pollicis brevis (of purely academic interest).

The Shaft of the Radius is Accessible: 1. Along the lower third of its lateral border (see procedure No. 2 for distal end of bone).

2. Along a narrow strip of the posterior surface situated between the insertion of the pronator teres and the origin of the abductor pollicis longus, the dissection passes superficially to the lateral side of the extensor digitorum communis, deeply between the abductor pollicis longus and the extensor carpi radialis brevis. By retracting the abductor pollicis longus a considerable area of the radius covered by this muscle can be exposed. The *middle third of the shaft* can be reached by this route.

3. The upper third of the posterior surface can be reached by a prolongation upward of the incision in No. 2 as far as the external epicondyle. The extensor digitorum communis is separated from the extensores carpi radialis longus and brevis and from the epicondyle and retracted medially. The supinator is exposed and retracted or divided secundum artem.

The Proximal End of the Radius is Accessible: 1. From behind by splitting the aponeurosis of origin of the extensor digitorum communis from the external epicondyle by a vertical

cut. If necessary open the joint by cutting the annular ligament and expose the head of the bone. To expose the neck, divide or retract the supinator muscle.

The Ulna

The shaft and both extremities of the ulna are subcutaneous from end to end. The epiphyseal line at the distal end of the bone is extra-articular everywhere except over a small area on its radial aspect. The proximal epiphyseal line is entirely extra-articular. The best method of exposing the bone is along its subcutaneous margin. In the distal part the incision passes between the tendons of the flexor and extensor carpi ulnaris. Care must be taken to avoid injuring the dorsal cutaneous branch of the ulnar nerve, which passes backward beneath the tendon of the flexor carpi ulnaris and becomes cutaneous in the distal fourth of the forearm. In plating fractures near the middle of the bone, care must be taken not to disturb unnecessarily the muscle attached to its anterior surface (flexor digitorum profundus), through the substance of which the nutrient artery passes to enter the arterial foramen, which is situated a little proximal to the middle of the bone. In operations on fractures of the olecranon process care must be taken not to injure the ulnar nerve. As the nerve passes distally between the two heads of the flexor carpi ulnaris it lies on the medial aspect of the base of the olecranon. It may be in real danger during the operation of subcutaneous wiring from side to side.

The Humerus

1. *Distal Extremity.* The capitellum and the trochlea form the articular surface of the lower end of the humerus. They lie entirely within the capsule of the joint. The lateral epicondyle (the center of ossification for which appears about the twelfth year) rests in close contact with the capitellum and lies outside the synovial cavity. The capitellum, trochlea and lateral epicondyle form the lower epiphysis. The medial epicondyle (the

center of ossification of which appears about the sixth year) is separated from the centers of the lower epiphysis by a growth downward of the shaft of the bone (Fig. 8). The line of attachment of the synovial membrane follows the lateral margins of the capitellum and the trochlear surfaces accurately. In front it is attached to the margin of the fossa radialis on the lateral side, thence passes up almost to the apex of the coronoid fossa and thence down to the margin of the trochlea on the medial side. On the posterior surface the attachment follows the margin of the capitellum until it reaches the edge of the trochlear surface, thence upward to the apex of the olecranon fossa and downward to the medial margin of the trochlea. Fig. 8 shows accurately the relationship of the lower epiphysis to the shaft and to the synovial cavity. The epiphyseal line is a considerable distance outside the joint line on the lateral side and just outside it on the medial side. In front and behind the epiphyseal line is intra-articular. In cases of separation of the lower epiphysis the lateral epicondyle, which forms part of it, is also displaced. The medial epicondyle remains attached to the shaft. Both radial and ulnar collateral ligaments remain for the most part intact and both ulna and radius are displaced with the epiphysis. If operative measures are deemed necessary the safest and simplest method is to reduce the epiphysis by traction on the forearm and forced flexion and then to drive a nail through the lateral epicondyle through the epiphysis into the shaft of the bone. The nail will not enter the joint cavity. Fractures through the lateral condyle usually start in the groove between the capitellum and the trochlea. They pass upward and laterally severing the capitellum and lateral epicondyle and part of the shaft from the rest of the bone. They can be treated by a nail driven obliquely through the lateral epicondyle into the shaft. The joint is not entered. Fractures through the trochlear surface commence in the deep notch in its center, which receives the wedge-shaped edge of the ulna. A simple fissure may start here which passes upward and medially into the shaft, separating part of the trochlear surface and medial condyle from the rest of the shaft. This can be

treated without opening the joint by driving a nail through the medial epicondyle upward and laterally into the shaft. T- and Y-fractures start at the same point in the trochlear surface. The line of fracture bifurcates medially and laterally at the upper end of the coronoid and olecranon fossa and passes to the sides of the shaft. The result is equivalent to a transverse fracture above the condyles with a vertical fissure into the joint. They can be fixed by nails which need not penetrate into the joint cavity. One nail enters at the lateral epicondyle and passes transversely across the capitellum and trochlear surface. Another enters at the lateral epicondyle near the first and passes upward and medially through the epicondyle and lower end of the shaft. Fractures of the shaft at a higher point than the olecranon fossa are best treated by splitting the triceps vertically in the middle line and plating the bone. In the description of the shaft of the humerus this will be treated more in detail. It will be seen that the lateral epicondyle is the key to the situation in the treatment of most of these fractures.

2. *Shaft.* The insertion of the deltoid muscle into the lateral aspect of the shaft of the humerus just above the radial groove marks a point in the bone just above its middle. It serves as a convenient landmark to locate fractures of the shaft of the bone. It will be employed in the following description as a convenient point around which to group a number of important anatomical structures:

A study of the *posterior surface* of the humerus (Fig. 9, *B*), shows that the medial head of origin of the triceps is attached to the whole aspect of its lower third and reaches proximally a point a little above the middle third, medial to the radial groove. Lateral to the radial groove from below upward can be seen part of the origin of the brachialis muscle, part of the deltoid insertion and the lateral head of origin of the triceps. The upper end of the last-named reaches almost as far as the insertion of the teres minor, which abuts directly on that of the infraspinatus. The radial groove occupies a very important position on the posterior surface of the bone. It is very oblique and occupies approxi-

mately the middle third of the shaft. In it lie the radial nerve and the arteria profunda brachii. A line drawn vertically upward along the middle of the posterior surface of the shaft of the humerus would touch the groove at a point near the lower part of the deltoid insertion. Near this point also an arterial foramen

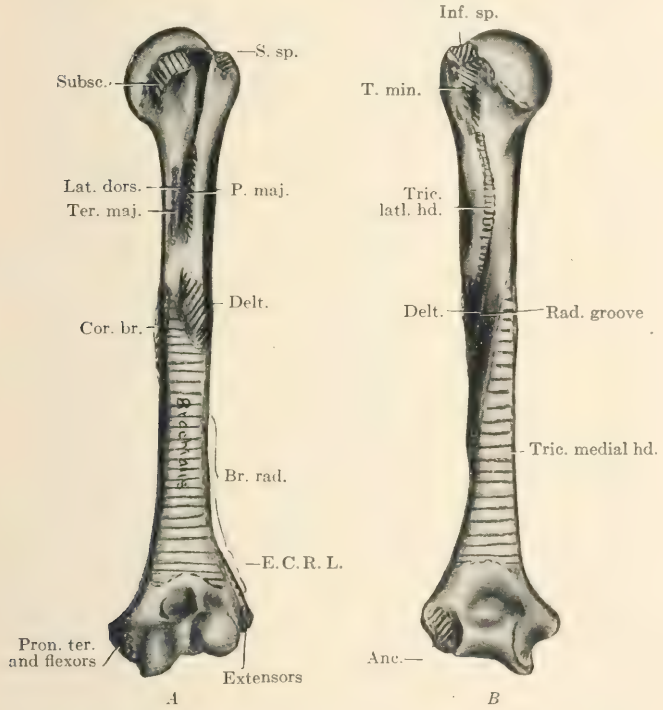

FIG. 9.—Anterior (*A*) and posterior (*B*) view of the humerus, showing muscular attachments. Notice the strategic position of the insertion of the deltoid muscle as an aid to group the anatomical structures. The radial groove is shown in relief in the posterior view.

in the bone is found in the groove. The radial groove contains structures so essential to the future well-being of the limb that it should never be interfered with unless the radial nerve has been injured in its course along it. It would therefore appear that the posterior aspect of the shaft in the neighborhood of the groove

should be avoided in choosing an operative field. Below the groove the bone is covered by the medial head of the triceps, the fibers of which pass into the deep surface of a broad tendon, which is inserted into the olecranon process. Access to this portion of bone is feasible and comparatively easy if the muscle is split vertically. If the line of cleavage is carried upward a little medial to the center of the posterior surface of the arm the bone can be exposed almost as high as the deltoid insertion without opening the radial groove. The split in the triceps does not appear to injure the nerve supply to the muscle because the nerves distributed to the medial head pass vertically downward in the muscular fibers parallel to the incision (Fig. 10).

The *anterior surface* of the bone is shown in Fig. 9, *A*.

(*a*) The *lower half* is covered by the origin of the brachialis muscle from the insertion of the deltoid proximally to the elbow-joint distally. Proximally the origin of the brachialis forms a V, the arms of which clasp the insertion of the deltoid. The medial portion of this V runs upward almost as high as the upper part of the deltoid insertion. Medial to it is the insertion of the coracobrachialis muscle. Occupying narrow strips of the lateral aspect of the lower part of this surface are the origins of the brachioradialis proximally and the extensor carpi radialis longus distally. Between the brachialis and the two last-named muscles lies the radial nerve. Superficial to the brachialis muscle lie the muscular belly of the biceps, the brachial artery with its venæ comites and the median nerve, also the ulnar nerve at its upper part. The artery and nerves are on the medial aspect of the biceps muscle. From the artery passes a branch to an arterial foramen in the bone. This trunk penetrates the upper and inner part of the brachialis muscle. The uppr end of the brachioradialis marks the position where the radial nerve pierces the intermuscular septum to get to the front of the arm. Superficially this point may be represented as the junction of the upper and middle thirds of a line drawn from the external epicondyle to the deltoid insertion. The only accessible part of the anterior surface of the bone is represented by an area on its upper and

lateral aspect medial to and below the deltoid insertion. This surface is covered by the brachialis muscle. This accessible

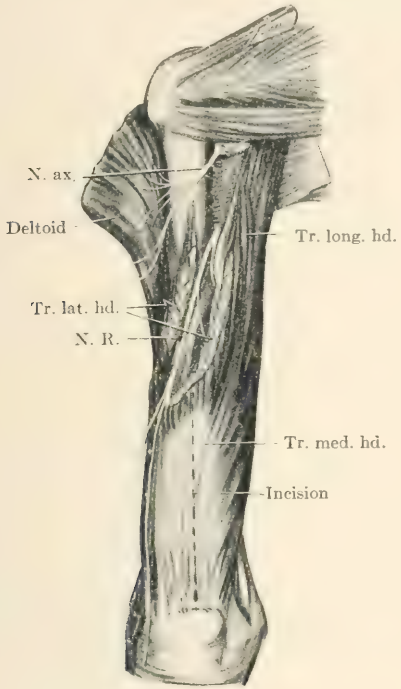

FIG. 10.—Dissection of the muscles on the posterior aspect of the arm. The medial head of the triceps has been left undisturbed. A dotted line running vertically shows the method of exposing the lower third of the shaft of the bone. The radial groove has been opened by dividing the lateral head of the triceps and the radial nerve is exposed. The deltoid muscle has been severed from the acromion process and spine of the scapula and retracted forward. The nerves supplying the muscle are shown. They are derived from the axillary nerve, the trunk of which can be seen passing through the quadrilateral space. Between the lateral head of the triceps and the posterior border of the deltoid near its insertion the shaft of the bone is accessible for a short distance.

area can be reached by an incision along the lateral aspect of the biceps muscle between it and the deltoid insertion. The incision can be carried downward as far as safety allows. It will expose

the insertion of the deltoid and the origin of the brachialis muscle which embraces it. The brachialis can then be split or peeled away from the bone. The musculocutaneous nerve will be retracted with the biceps and will be in no danger. The nerve supply to the brachialis (from the musculocutaneous and from the radial) will also be safe. If necessary the insertion of the deltoid can be peeled from the bone.

(*b*) The *upper part* of the anterior surface of the humerus (Fig. 9, *B*) shows the intertubercular groove in which rests the long tendon of the biceps. The insertions of the pectoralis major (to the lateral lip) of the latissimus dorsi (to the floor) and the teres major (to the medial lip) can be seen. The pectoralis major covers the whole of this area as far as the lateral lip and the groove can only be exposed after division of its tendon of insertion (Fig. 11). Proximally to the insertion of the teres major, that of the subscapularis into the smaller tubercle can be seen. An area on the outer surface of the upper third of the shaft bounded by the deltoid insertion distally, the insertions of the supraspinatus, infraspinatus and teres minor proximally, the lateral lip of the intertubercular groove anteriorly and the lateral head of the triceps posteriorly is free from any muscular attachments. It is covered by the muscular mass of the deltoid. Winding around the upper part of this area just below the tubercles are the nerve (axillary) and the artery (arteria circumflex posterior) which supply the deltoid. The part of the bone in contact with these structures is the "surgical neck." The nerve and artery come from the axilla by passing through the quadrilateral space. A study of Fig. 10 will show that an attempt to reach the surgical neck of the humerus by an incision along the posterior border of the deltoid would invite disaster by endangering the nervous and vascular supply to the deltoid. The upper portion of the shaft below the surgical neck is accessible by this route. If care is taken to keep superficial to (*i. e.*, anterior to) the lateral head of the triceps the radial nerve would be avoided. It would, however, be a difficult route and should be reserved for special cases of open fracture with the wound in this situation.

The best route both for the surgical neck and for the upper portion of the shaft as low down as the insertion of the deltoid is in front. If an incision is made between the pectoralis major and deltoid it can be carried upward and downward as far as

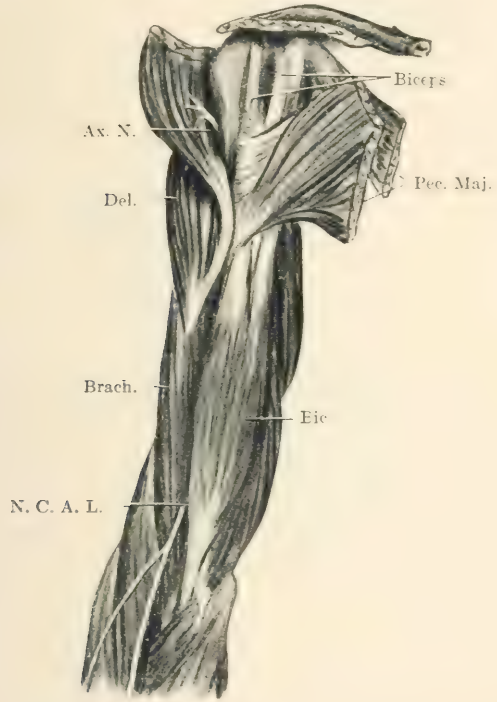

FIG. 11.—A dissection of the muscles on the anterior aspect of the arm. The insertion of the pectoralis major has been left intact. Above it the tendons of the long and short heads of the biceps are shown. The deltoid muscle has been detached from the clavicle and acromion process and thrown backward, exposing the upper end of the shaft of the humerus and the greater tubercle. The axillary nerve is shown. The nervus cutaneus antebrachii lateralis (*O. T.*, musculocutaneous) is shown near the bend of the elbow.

may be required. In the lower part of the field the bone can be exposed with ease between the insertion of the deltoid and the medial head of the origin of the brachialis. A little more proximally the bone can be exposed lateral to the insertion of the

pectoralis major by vigorous lateral traction of the deltoid. The pectoralis major covers the anterior part of the surgical neck. The lateral aspect of the neck may be brought into view by

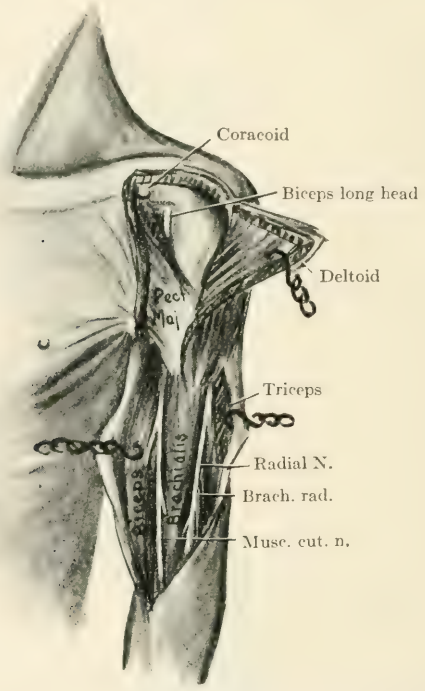

FIG. 12.—Dissection of anterior surface of arm to show method of access to upper two-thirds of the shaft of the humerus by a safe route. The deltoid muscle has been divided near its clavicular and acromial origin and retracted laterally. The belly of the biceps muscle has been retracted medially. The upper end of the shaft of the humerus and the greater tubercle is exposed. By working between the insertion of the pectoralis major and deltoid still more of the shaft could be exposed, and by splitting the brachialis distally along the same line the anterior surface of the shaft could be exposed to a low level. With reasonable care there would be no danger of injuring the musculocutaneous or radial nerves. (Original dissection.)

retraction of the deltoid, or, better still, by transverse section of the anterior part of the deltoid near its origin from the clavicle and acromion process. If this is done the nerve supply to the

muscle will not be hurt. Ample room is obtained and subsequent suture of the muscle will restore its function. Figs. 11 and 12 show such a division of the deltoid with thorough exposure of the tubercles and surgical neck of the humerus. Many surgeons prefer to split the deltoid and to approach this aspect of the shaft on its outer aspect. This has the grave objection that all the muscular fibers in front of the incision will atrophy.

3. *Proximal Extremity.* The proximal extremity of the humerus consists of the head and the larger and smaller tubercles (Fig. 9). Below the tubercles the contracted portion of the shaft is called the surgical neck. The head consists of about one-third of a spheroid. It is attached to the posterior medial and upper end of the shaft and the center of the spheroid points backward and medially. It is covered with articular cartilage. Around its margin is a shallow groove, well marked above, but smooth with the shaft below. This is known as the anatomical neck and to it the capsule of the joint is attached. Lateral to the groove is the prominence of the greater tubercle above and the lesser tubercle in front. Between the tubercles is the intertubercular groove (bicipital). The head and the greater and lesser tubercle form the upper epiphysis which sits on the pointed end of the diaphysis like a cap. The epiphyseal line lies within the articulation on the medial aspect of the joint, but well outside the joint on the lateral aspect. In front it is in direct relationship with the intertubercular (bicipital) groove and hence with the joint. In cases of separation of the proximal epiphysis the proximal end of the diaphysis is usually displaced laterally and upward and lies under the deltoid muscle. The epiphysis is tilted sideways. In cases in which operation is necessary the deltoid fibers can be split for a limited space over the outer aspect of the joint just below the tip of the acromion process. If the case is recent, traction on the shaft will draw the upper end of the diaphysis downward. A sharp hook should now be placed into the greater tuberosity, and by pulling downward the epiphysis can be replaced on the upper end of the shaft. It may be sutured in position by silver wire or kangaroo tendon or nailed to the shaft by a peg. There is no

risk of opening the joint. In old standing cases in which we are unable to dislodge the upper end of the diaphysis by traction, and in which quite a long deltoid incision would be needed to give sufficient room, it would be better to make a vertical cut along the anterior border of the deltoid through which the muscle could be separated from the pectoralis major, and to supplement this by a transverse incision just below the acromioclavicular arch along which the deltoid could be divided and retracted posteriorly and distally, toward its vascular and nervous supply. By this means a perfect view of the upper end of the shaft of the humerus, surgical neck and tubercles, would be obtained without permanent damage to the muscle. Subsequent suture would restore the integrity of the deltoid completely.

The region of the intertubercular (bicipital) groove and the lesser tubercle can be exposed by an incision between the deltoid and pectoralis major. The long tendon of the biceps comes into view as it passes downward between the tubercles. The joint can be opened by incising the capsule along the tendon. By rotating the humerus outward the lesser tubercle, with the insertion of the subscapularis into it, comes clearly into view.

Recapitulation. From the foregoing we may safely draw the following conclusions:

1. To expose the shaft in the *lower third*, the bone can be reached safely by the posterior route, the deep dissection splitting the triceps muscle parallel to its fibers.

2. To expose the shaft in the *middle third*, one has choice of two routes: (*a*) the safest is the anterior, which passes between the biceps and the insertion of the deltoid in its upper part and along the outer edge of the biceps in its lower part. The bone is exposed medially to the deltoid insertion and laid bare by splitting or peeling off the origin of the brachialis muscle; (*b*) the lower part of this area can be reached from behind by splitting the triceps. The field of operation is, however, limited above by the radial groove which is too near for safety.

3. To expose the shaft in the *upper third* the anterior route between the pectoralis major and the deltoid is the best and the

safest. The route along the posterior margin of the deltoid endangers the nervous and vascular supply to the muscle too seriously. It should not be forgotten, however, that if due care is exercised the bone *just above* the deltoid insertion can be exposed with comparative safety by dissecting carefully between the posterior edge of the deltoid and the lateral head of the triceps.

Articular Ends of the Humerus. 1. *Lower Articular End.* The lateral aspects of the condyles can be reached through small incisions directly over their prominent subcutaneous parts. If necessary the incisions can be carried upward along the external and internal muscular septa and the deep dissection carried to the bone along this plane. The soft parts can be separated from the bones on their anterior and posterior aspects and sufficient room obtained to treat foci of osteomyelitis or, in the case of fractures, to fasten the fragments together with screws or nails. Plating is difficult through such incisions. To apply a plate properly as may be required in T-fractures the best route is a posterior vertical incision which splits the triceps muscle near its insertion.

2. *Upper Articular End.* An incision along the anterior margin of the deltoid gives the best exposure in most cases. If supplemented by a transverse cut backward through the deltoid muscle near its origin the exposure of the upper articular extremity is so complete that fractures of the anatomical neck and of the tubercles and foci of osteomyelitis can be dealt with in a very satisfactory manner. In uncomplicated cases of fracture of the greater tubercle a small puncture might be made through the deltoid and a nail driven through the tubercle into the shaft to pin it in place. The head of the nail can be left outside the skin incision to facilitate removal when the bony surfaces have united.

The Lower Extremity

The Tibia. 1. *Distal Extremity.* This is roughly quadrangular in shape. The lower surface is covered with cartilage and articulates with the talus. The *anterior surface* is covered by the tendons of the tibialis anterior, the extensor pollicis longus

and the extensor digitorum communis as they course from the leg to the foot. The anterior ligament of the ankle-joint is attached along a groove just proximal to the articular surface. The *posterior surface* is covered by the tendons of the flexor pollicis longus, the flexor digitorum longus and the tibialis posterior as

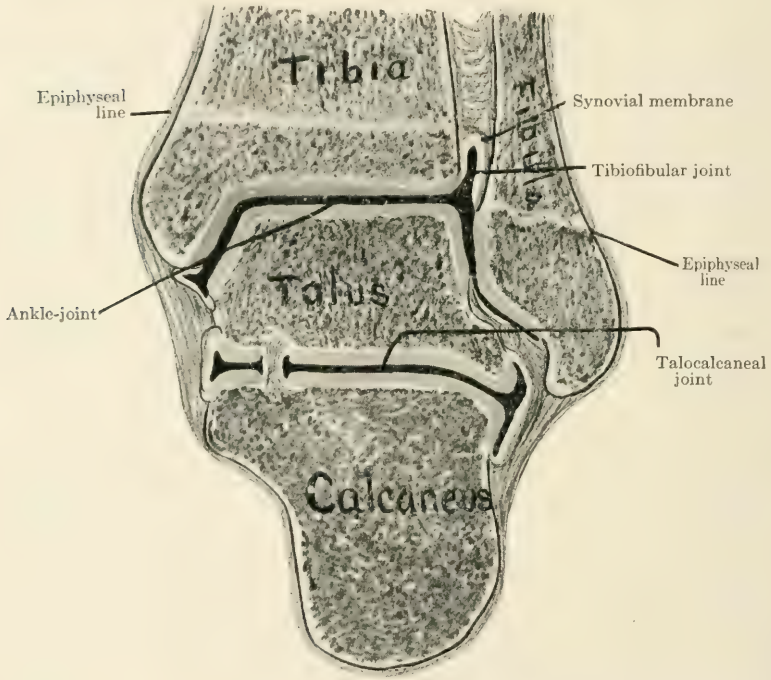

FIG. 13.—Represents a coronal section of the ankle-joint. It shows that the epiphyseal line of the distal end of the tibia is entirely outside the joint cavity. That of the fibula impinges on the joint on its medial aspect. Note the prolongation of the lower tibiofibular joint almost as high up as the epiphyseal line of the tibia.

they pass to the sole of the foot. The last two structures pass in a groove (sulcus malleolaris) which runs along the posterior border of the malleolus (Fig. 15). The *lateral surface* is applied to the fibula over a triangular area to which strong fibers of the interosseous ligament are attached. Part of this area is often

covered by cartilage and forms a part of the synovial cavity of the ankle-joint (Fig. 13). The *medial surface* is prolonged downward into the medial malleolus, the medial surface of which is subcutaneous. To its apex the strong deltoid ligament is attached.

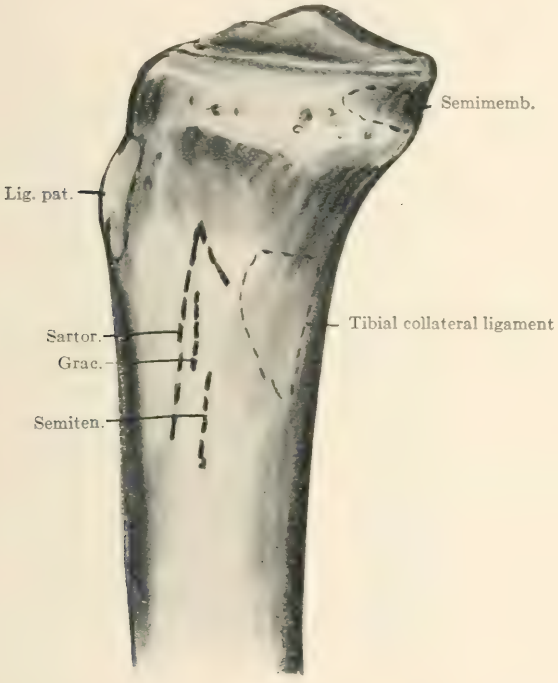

FIG. 14.—Represents the medial surface of the proximal end of the tibia. The area between the insertions of the sartorius and the ligamentum patellæ gives access to the upper end of the diaphysis and the epiphyseal line. The medial surface of the shaft below the insertion of the semitendinosus is free from muscular attachments.

Along its posterior border there is a distinct, broad, oblique groove which accommodates the tendons of the tibialis posterior and the flexor digitorum communis (Fig. 15). The epiphyseal line is entirely outside the joint cavity (Fig. 13). The medial surface, including the malleolus, is subcutaneous and accessible. It is

exposed frequently in open operations for fracture (Pott's fracture, separation of lower epiphysis, etc.), and in cases of osteomyelitis in the neighborhood of the epiphyseal line.

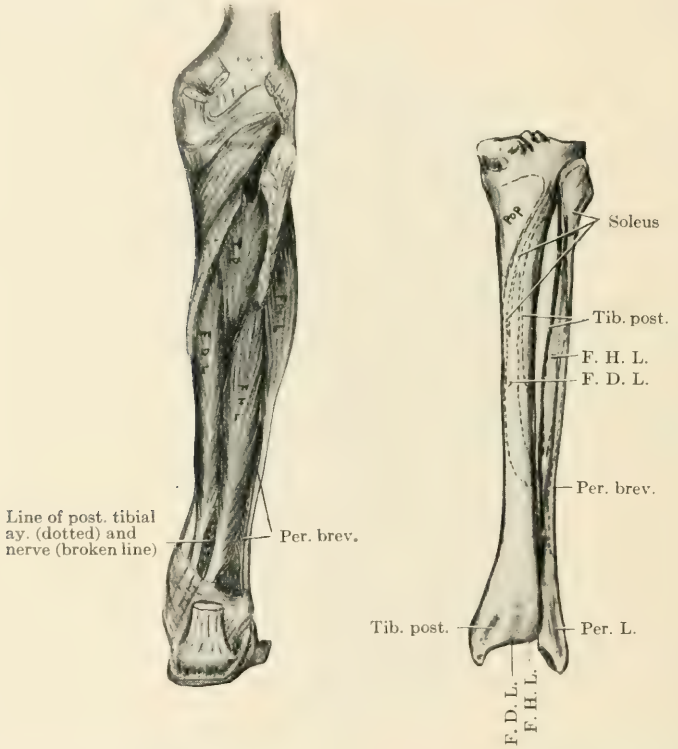

FIG. 15.—Represents on the right the posterior aspects of the tibia and fibula, with the muscular attachments to the bones; on the left a dissection of the deep muscles of the posterior aspect of the leg. On the bones (right) the large area of the posterior aspect of the lower third of the tibia, to which no muscles are attached, is well shown. At its distal extremity the tendinous grooves are seen. On the posterior aspect of the lateral malleolus the groove for the peronei tendons is seen. The muscular dissection (left) shows by dotted and broken lines the position of the posterior tibial artery and the tibial nerve lying between the tendons of the flexor digitorum longus and flexor hallucis longus. It is through this interval that the bone is exposed for tendon implantation.

2. *The Shaft.* The medial surface of the shaft of the tibia is subcutaneous from end to end except in its upper fourth, where the tendons of the sartorius, gracilis and semitendinosus overlap it (Fig. 14) as they pass to their insertions. It is the most accessible surface of the bone, and for that reason operations on fractures and inflammatory foci are always conducted from this side. Areas of osteomyelitis in the upper end of the diaphysis can be reached by an incision placed between the insertions of the sartorius and the ligamentum patellæ. By peeling the insertions of these tendons from the bone and preserving the periosteum to which they are intimately attached, large areas of diseased bone can be removed without jeopardizing the subsequent reproduction of the upper end of the shaft. The lower end of this surface passes distally into the medial malleolus, which is also subcutaneous. The surface of the shaft proximal to the malleolus is frequently exposed in orthopedic operations. In cases of talipes valgus the tendon of the tibialis anterior is exposed, dislocated and fastened into a vertical groove made in the medial surface of the tibia (Galli). In cases of talipes equinus the same surface is pierced with a drill and artificial silk ligaments (Bartow, Bradford), or fascial strips are passed through the drill holes, the other ends being passed through the bones of the tarsus on their dorsal surfaces.

The *lateral surface* of the tibia is bounded in front by the anterior crest (shin) and behind by the interosseous crest. From its proximal two-thirds the tibialis anterior muscle arises. It is very deep and inaccessible and is on that account never exposed. In its distal third this surface passes to the front, where it is easily accessible. No muscles arise from its surface but over it the tendons of the tibialis anterior, the extensor hallucis longus and the extensor digitorum communis pass obliquely on their way to the foot. On it lie also the anterior tibial artery and the deep peroneal nerve. The artery and nerve lie in close contact with each other, the nerve being placed laterally. Both structures are deeply situated and lie in close contact with the periosteum. The tibialis anterior lies to the medial side of the artery. Just

above the ankle-joint the artery is crossed superficially from the lateral to the medial side by the tendon of the extensor hallucis longus. The extensor digitorum longus lies to the lateral side of

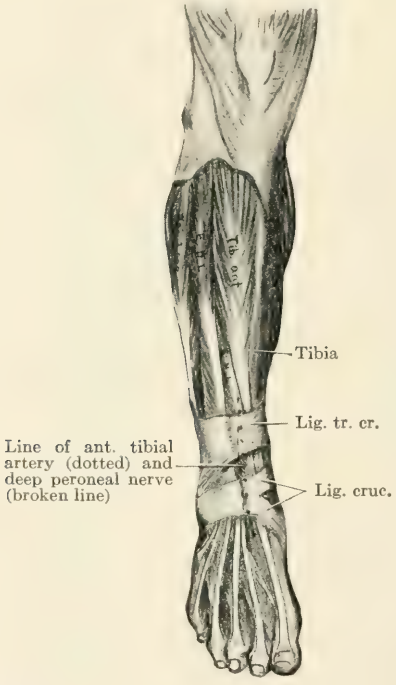

FIG. 16.—Represents a dissection of the muscles on the front of the leg. It shows also the subcutaneous portion of the medial surface of the tibia. Just above the ankle-joint the tendons are bound down by the ligamentum transversus cruris. Here the lines of the anterior tibial artery and the deep peroneal nerve are represented by dotted and broken lines. The bone (tibia) is exposed by passing between the tendons of the tibialis anterior and the extensor hallucis longus and retracting the tendon of the hallucis to the lateral side.

the vessel (Fig. 16). It would be possible to utilize this surface for tendon fixation in cases of paralytic toe-drop in the following manner: A vertical incision is made along the lateral border of the tendon of the tibialis anterior. The ligamentum

transversum cruris is incised and the extensor tendons exposed. The artery and nerve will be found lying underneath the extensor hallucis longus. If the tendon of this muscle is retracted to the lateral side, the anterior tibial artery and nerve will be exposed lying on the lower end of the tibia. The artery and nerve can be retracted from side to side while a groove is made in the bone in which the distal ends of the tendons are fixed. Finally the artery and nerve are put back in place between the tendons. It is found, however, that silk tendons and fascial transplants passed through drill holes in the subcutaneous inner surface of the lower end of the tibia above and through the tarsal bones below is a much better operation for toe drop.

The Posterior Surface of the Shaft. Practically all of the upper three-quarters of this surface is covered by muscles which are attached to it (Fig. 15). They are the popliteus, soleus, flexor digitorum longus and the tibialis posterior. The large arterial foramen, along which passes the nutrient artery of the bone, is placed at the junction of the upper and middle thirds of the bone in the area covered by the tibialis posterior. The popliteal vessels and the tibial nerve lie on the posterior surface of the popliteus muscle as far as its lower border. Distal to this point (where the popliteal divides into the anterior and posterior tibial branches) the posterior tibial artery and the tibial nerve lie on the posterior surface of the tibialis posterior muscle. The nerve lies lateral to the artery. Superimposed on the above-named structures lie the fleshy masses of the gastrocnemius and the soleus and the tendo-Achillis. It will be evident that this surface of the bone should never be exposed deliberately. The *lower quarter* of this surface has no muscles arising from it or inserted into it. It is covered completely by the tendons of the tibialis posterior, flexor digitorum longus and the flexor hallucis longus (Fig. 15). Between the last two lie the posterior tibial artery and the tibial nerve. Both structures lie on the bone and the nerve is lateral to the artery. A short distance above the ankle-joint the tendon of the tibialis posterior slips medially between the tibia and the tendon of the flexor digitorum longus. It then

passes downward under the ligamentum laciniatum in a groove on the back of the median malleolus invested in a special synovial sheath. Parallel to it and placed laterally in a special synovial sheath courses the flexor digitorum longus tendon. Lateral to this in order lie the posterior tibial artery and the tibial nerve. Lateral to these structures, enclosed in a special synovial sheath and lying in a special groove in the tibia, lies the tendon of the flexor hallucis longus. This tendon is deeply situated but can be recognized by the fleshy fibers which enter its lateral aspect almost as low down as the synovial sheath. This surface is of great surgical interest, inasmuch as it is frequently exposed by surgeons for the purpose of implanting the distal end of the tendo-Achillis into a groove made into the bone for the relief of paralytic talipes calcaneus. After exposure and division of the tendo-Achillis by an incision along its medial border the deep fascia of the leg is divided medial to the flexor hallucis longus. The posterior tibial artery and nerve are retracted medially and the flexor hallucis longus laterally and the posterior surface of the bone exposed. After gouging a groove deep into its medullary cavity the distal end of the divided tendo-Achillis is fixed in the cavity and the periosteum closed over it (Galli).

3. *The Proximal Extremity.* The proximal end consists of the medial and lateral condyles (tuberosities), the intercondyloid eminence (spine) and the tuberosity (tubercle). This practically corresponds to the whole upper epiphysis of the bone. The epiphyseal line is entirely extra-articular as regards the knee-joint. On its lateral aspect it passes through the cartilaginous area which forms the tibial part of the proximal tibiofibular joint (Fig. 17). On the medial side it is considerably distal to the knee-joint and reaches the surface of the bone in the substance of the tibial collateral ligament. Anteriorly it curves downward distal to the tubercle of the tibia (Fig. 20). Posteriorly it reaches the surface considerably distal to the attachment of the posterior ligament of the knee-joint (Fig. 20). The anterior and medial surfaces of the medial condyle are subcutaneous and accessible. The posterior surface

is inaccessible, being occupied by the insertion of the semimembranous tendon and covered by the tendons of the sartorius, gracilis and semitendinosus. The lateral epicondyle is accessible in front of and proximal to the upper tibiofibular articulation.

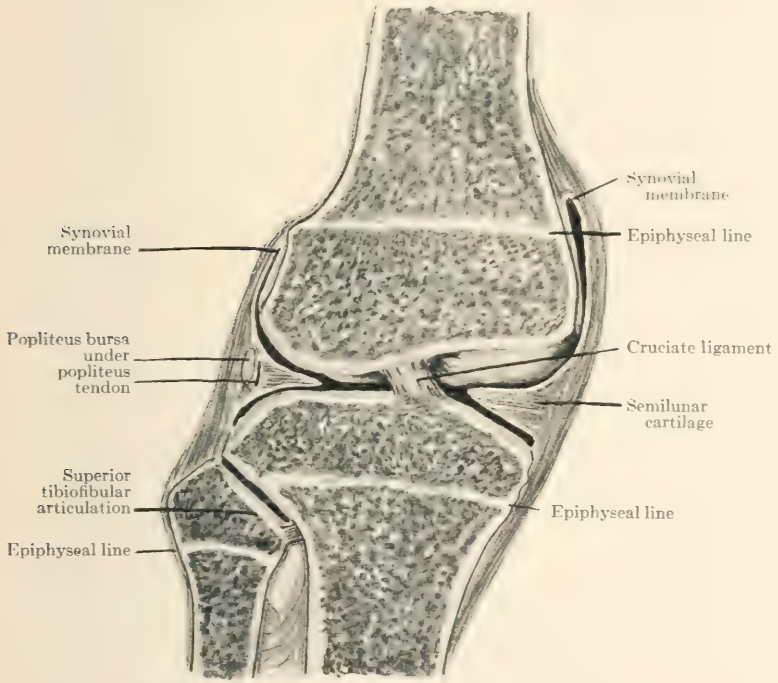

FIG. 17.—Represents a coronal section of the femur and tibia and fibula through the knee-joint. The epiphyseal line of the tibia is extra-articular as regards the knee-joint. On its lateral side it communicates with the proximal tibiofibular joint. The epiphyseal line of the fibula is extra-articular. The epiphyseal line of the femur is extra-articular on the lateral side; on the medial side the reflexion of the synovial membrane passes proximal to it. A study of Fig. 19 will explain this.

Behind this the tendon of the biceps and the common peroneal nerve are superficial to it. The tuberosity is accessible at its distal extremity below the attachment of the ligamentum patellæ (Fig. 14). Proximally the ligamentum patellæ covers it and is separated from it by a bursa (Fig. 20).

The Fibula. 1. *The Distal Extremity.* The distal extremity of the fibula or lateral malleolus is of a pyramidal shape. It is situated on a plane posterior to and extends farther toward the sole of the foot than the medial malleolus (Fig. 13). Its lateral surface is subcutaneous and is continuous with a triangular-shaped lateral surface on the lower part of the shaft. To the apex of the malleolus and to its anterior border are attached ligaments. Its posterior border shows a deep groove in which the tendons of the peroneus longus and brevis lie. The medial surface has a triangular articular area which articulates with the lateral surface of the talus. Behind this is a deep depression in which the posterior talofibular ligament is attached. The line of separation between the epiphysis and diaphysis corresponds to the level of the joint between the tibia and the talus. It communicates with the ankle-joint (Fig. 13). Above the epiphyseal line the lower end of the diaphysis is in contact with the synovial prolongation of the ankle-joint, which lines the lower tibiofibular articulation. The whole of this part of the bone is accessible from its subcutaneous aspect. It is accessible in fractures of the external malleolus in cases of tuberculous osteomyelitis and rare cases of acute osteomyelitis.

2. *The Shaft.* On the lateral surface of the distal extremity of the shaft of the fibula there is a triangular area bounded by two ridges which can be traced above into the anterior crest (Fig. 18). At the apex of this triangle the origins of the peroneus brevis and peroneus tertius diverge from one another. This is the most accessible portion of bone and it is quite frequently exposed in the open operative treatment of Pott's fracture. This surface passes below into the outer surface of the lateral malleolus. The posterior surface of the lateral malleolus is grooved deeply and contains the tendons of the peronei muscles, the longus being most superficial. The outer surface of this part of the bone is utilized for tendon fixation in cases of paralytic talipes varus. A deep groove is made in it and the peroneus longus dislocated and fastened firmly in the groove. The original peroneal groove on the posterior aspect is deepened and the peroneus brevis fixed in it.

The rest of the fibula is covered by muscles. From the medial surface (the part between the anterior and interosseous crests) arise the extensor digitorum communis, the peroneus tertius and

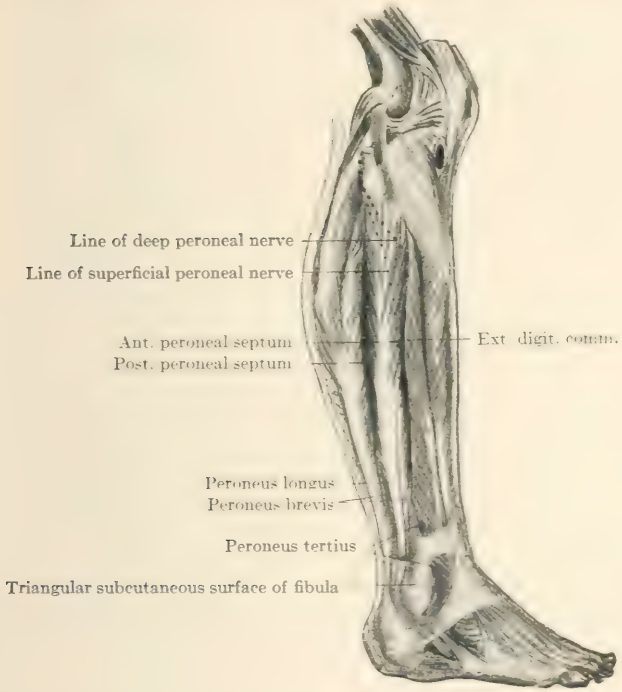

FIG. 18.—Represents a dissection of the muscles on the lateral aspect of the leg. It shows the triangular subcutaneous portion of the fibula at the lower part and above this the peronei muscles covering the lateral surface of the fibula. The anterior and posterior peroneal septa are designated. The lines of the deep peroneal nerve in the substance of the peroneus longus, on its way to the front of the leg, are shown by the upper oblique dotted line. That of the superficial peroneal nerve (musculocutaneous) in its intramuscular course is shown by the lower oblique dotted line.

the extensor hallucis longus. From the lateral surface (between the anterior and lateral crests) arise the peroneus longus (proximally) and the brevis (distally) muscles. From the posterior surface (between the lateral and interosseous crests) arise the

soleus muscle (proximally) and the flexor hallucis longus (distally). Dipping down between these three groups of muscles are two strong intermuscular septa, which have firm attachment to their respective crests. The one which passes between the peroneus longus and brevis muscles behind and the extensor digitorum communis and peroneus tertius in front is called the "anterior peroneal septum." The other which passes between the peronei in front and the calf muscles (soleus and flexor hallucis longus) behind is called the posterior peroneal septum. The superficial peroneal nerve lies in a sheath in the anterior peroneal septum after it pierces the fibers of the peroneus longus muscle. It becomes cutaneous in the distal third of the leg by piercing the deep fascia. There is no structure in the way of approaching the bone along the posterior intermuscular septum, which is therefore the route of choice. Blunt dissection behind the peronei will enable us to separate the muscular fibers from the septum until the crest of the bone is reached. In the upper third of the shaft the dissection will pass between the peroneus longus and the soleus. Care must be taken not to injure the deep peroneal nerve as it winds around the neck of the fibula in the substance of the peroneus longus muscle. Roughly its position is about one inch below the most prominent part of the head of the fibula. In the middle third of the leg the dissection passes between the peroneus longus and the flexor hallucis longus.

3. *The Proximal Extremity.* The proximal extremity of the fibula consists of the head (capitulum) which joins the shaft by a constricted portion called the neck. The head articulates by an area of triangular shape with the lateral condyle of the tibia. To the apex of the head is attached the short fibular collateral ligament and part of the tendon of the biceps. In front of the head there is a prominent tubercle from which the peroneus longus muscle arises. Behind the head is a tubercle from which the soleus muscle arises. A very narrow area of the bone is accessible between the attachments of these muscles and the attachment of the fibular collateral ligament. To expose the rest of the head and the neck of the bone the muscles attached to it must be elevated

and retracted downward. The epiphyseal line is entirely extra-articular as regards the tibio-fibular joint and is situated just below the expanded part of the head of the bone (Fig. 17). Great care must be taken in exposing the neck of the fibula not to injure the deep peroneal nerve.

THE FEMUR. 1. *The Distal Extremity.* By this we mean the epicondyles and condyles. The anterior, posterior and inferior surfaces of the medial and lateral condyles are covered with cartilage and lie inside the capsule of the knee-joint. The anterior and posterior cruciate ligaments are attached to the intercondyloid fossa, which is a deep space lying between the condyles posteriorly (Fig. 17). The patella lies in the groove between the condyles in front. It would be impossible to expose the bone from in front or behind without opening the joint cavity. The lateral aspect of each condyle is subcutaneous and on each there is a projection called the epicondyle (Fig. 19 *x*). The medial projects very prominently. It is capped by the adductor tubercle and to it are attached the fibers of the tibial collateral ligament of the knee-joint. It corresponds to the epiphyseal line. The lateral epicondyle is not so prominent. Just distal to its most prominent part the popliteus tendon lies in its bony groove, while just posterior to it is attached the fibular collateral ligament. The synovial membrane is attached to the femur all around the line of junction of bone and cartilage. The actual joint cavity, however, overlaps the lateral and anterior (Fig. 20) aspects of the bone to a large extent and makes it necessary for us to plan an incision outside the line of reflexion of the synovial membrane, so as to peel it from its recesses and to uncover the bone. The lower surface of the shaft in front is covered by the upper part of the synovial cavity for quite a distance above the level of the upper border of the patella, but the synovial membrane can be peeled from this surface as low down as the cartilaginous margin without opening the joint cavity. Similarly on the lateral aspects of the condyles an area in front of each epicondyle is overlapped by the lateral recesses of the joint cavity. The drawings in Fig. 19, representing the lateral and medial

aspects of the condyles, show by dotted lines the actual line of attachment of the synovial membrane and its line of reflexion. The line of attachment is shown by the dotted line *b*, that of reflexion by the dotted line *a*. The line *c* represents the fusion of *a* and *b*.

Lateral surface. Medial surface.

FIG. 19.—Represents lateral views of the distal extremity of the right femur. Each epicondyle is shown by a cross. The line of attachment of the synovial membrane to the bone is shown by the dot-and-dash line *b;* the line of reflexion by the dotted line *a*. At *c* the two lines coincide and pass across the posterior aspect of the bone. On the lateral surface, distal and posterior to the prominence of the epicondyle, a deep groove, from which the popliteus takes its origin, is clearly shown.

The area proximal to and behind the dotted line showing the line of reflexion of the synovial membrane is absolutely safe for surgical approach. It will be seen that both lateral and medial epicondyles (shown by a cross) are outside this area and that there is a considerable area of bone above and behind these prominences, directly accessible. A vertical incision extending

proximally from the epicondyles could be carried down to bone without risk of opening the knee-joint. On the medial side (Fig. 21) it would cut through the aponeurotic expansion passing from the vastus medialis to the side of the patella and at a higher

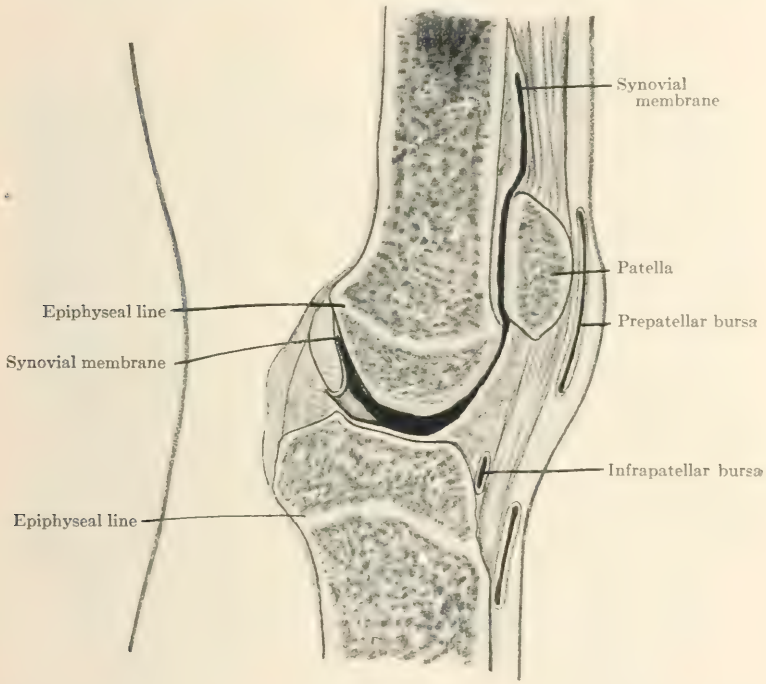

FIG. 20.—Represents a median sagittal section through the knee-joint. It shows the prolongation of the synovial membrane upward above the patella and the anteroposterior relationships of the epiphyseal line to the knee-joint. In front the line is very close to the attachment of the synovial membrane; behind it is a short distance proximal to the joint. The epiphyseal line of the tibia is seen to be far removed from the joint cavity.

level the vastus medialis muscle itself. On the lateral aspect it would split the iliotibial band of fascia lata tractus iliotibialis and also at a much higher level sever the fibers of the vastus lateralis. By peeling the deeper structures from the bone backward and forward a large area could be exposed for operative

procedures. In front the reflexion of synovial membrane would be brushed away and there would be no danger of opening the articulation. This is the route of choice in osteomyelitis of the epiphysis and the lower end of the diaphysis. In fractures through the condyles and T-fractures nails or screws can be inserted in this area.

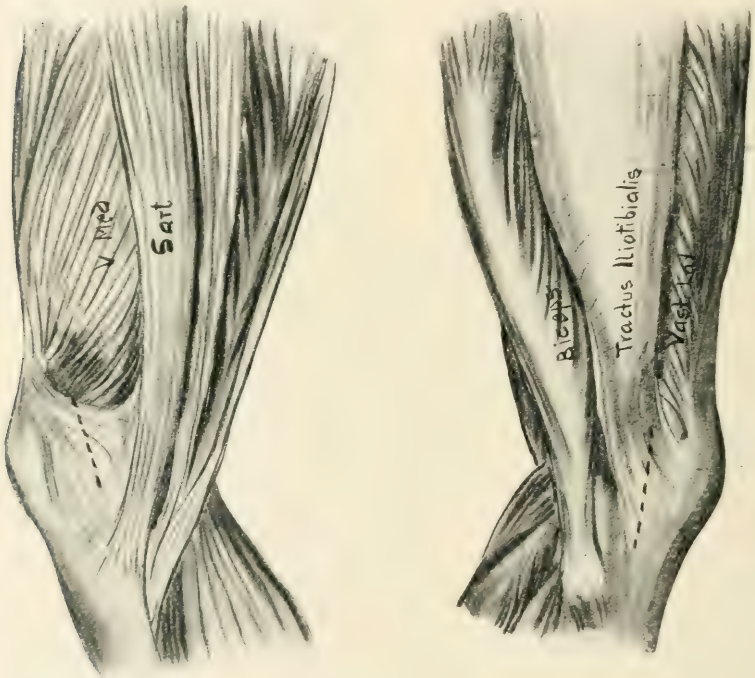

FIG. 21.—Represents a dissection of the muscles on the medial and latera aspects of the lower end of the femur and knee-joint. The broken vertical lines show the incisions employed to expose the outer surfaces of the condyles and the lower end of the shaft. The lowest point corresponds to each epicondyle. Notice the respective levels of the vastus medialis and vastus lateralis. Notice also the solidity and strength of the tractus iliotibialis. (The vertical lines are not quite correct. The upper ends should be more posterior.)

2. *The Shaft.* This is so closely and massively invested by muscles that it is only accessible to a slight extent by incisions which pass between the muscular masses.

The Posterior Surface. There is a triangular area on the posterior surface of the lower end of the shaft, which is bare of muscular attachments (Fig. 22). It is bounded laterally by the attachment of the short head of the biceps and medially by the part of the adductor magnus descending to the adductor tubercle.

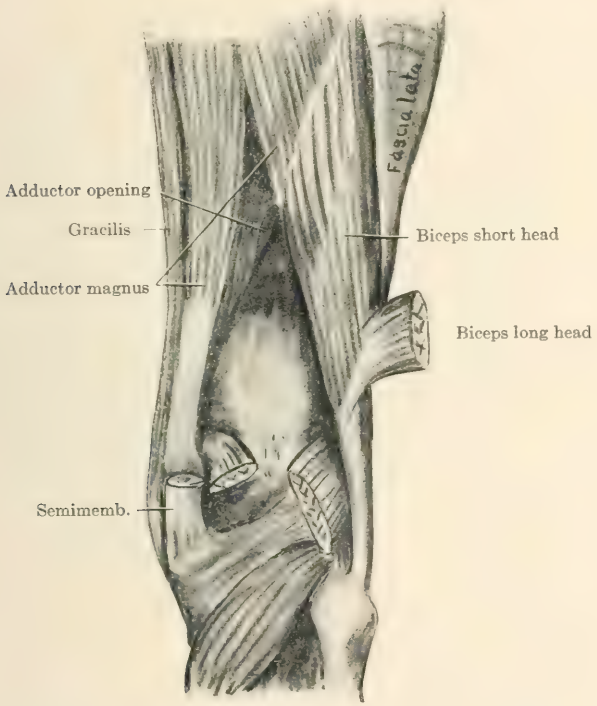

FIG. 22.—Represents a dissection of the deep muscles bounding the popliteal space. It is intended to show the method of access to the posterior surface of the femur lateral to the tendon of the adductor magnus. The adductor opening through which the femoral artery and vein pass is shown by a kite-shaped slit.

It forms the floor of the popliteal space. Resting on this surface are the popliteal artery and vein and the upper geniculate vessels. This surface is accessible by a vertical incision along the line of the adductor magnus tendon. The deep dissection passes in

front of the inner hamstrings, which are retracted posteriorly. After exposure of the tendon of the adductor magnus, that structure is retracted forward. If the popliteal vessels are retracted laterally a considerable area of bone can be exposed. The incision is commonly used for ligature of the popliteal artery (Jobert). It has been employed by me a few times for the removal of sequestra from the lower end of the femur and for the dissection of synovial cysts from the popliteal space. In one case of osteomyelitis, with a sequestrum partly within and partly without its involucrum, I detached the adductor magnus from the bone over a considerable area, retracting it proximally along with the femoral artery and vein. The rest of the posterior surface of the shaft is so closely invested with muscles (adductors, quadratus femoris, gluteus maximus and biceps cruris) over which lie the hamstrings and the great sciatic nerve that it may be considered as inaccessible.

The *antero-external surface* of the femur, by which we mean the surface between the insertions of the adductors (pectineus, adductor longus and brevis and adductor magnus) and the line of origin of the vastus lateralis, is covered by the vasti muscles as by a blanket (Fig. 23). The vastus intermedius covers it anteriorly and laterally in its lower three-quarters. The same muscle also covers the anterior aspect of the upper quarter. The vastus medialis covers the medial aspect of this surface from the spiral intertrochanteric line above as far as the upper border of the medial condyle below. The vastus intermedius is overlapped on its medial aspect by the vastus medialis from end to end. The free anterior or lateral border of the vastus medialis corresponds to a line running vertically upward along the middle of the front of the thigh. The lateral aspect of the vastus intermedius is overlapped by the vastus lateralis over the whole of its lower three-quarters. In the upper quarter the intermedius is no longer attached to the lateral aspect of the bone, and here the vastus lateralis invests the bone closely. Between the anterior margins of the vastus medialis and the vastus lateralis the rectus femoris is wedged. It lies on the anterior surface of the

vastus intermedius. In the upper two-thirds of the thigh (Fig. 24) the rectus can be separated with ease from the vasti muscles. Fig. 23 represents a transverse section of the thigh through the middle of Hunter's canal and shows the manner in which the

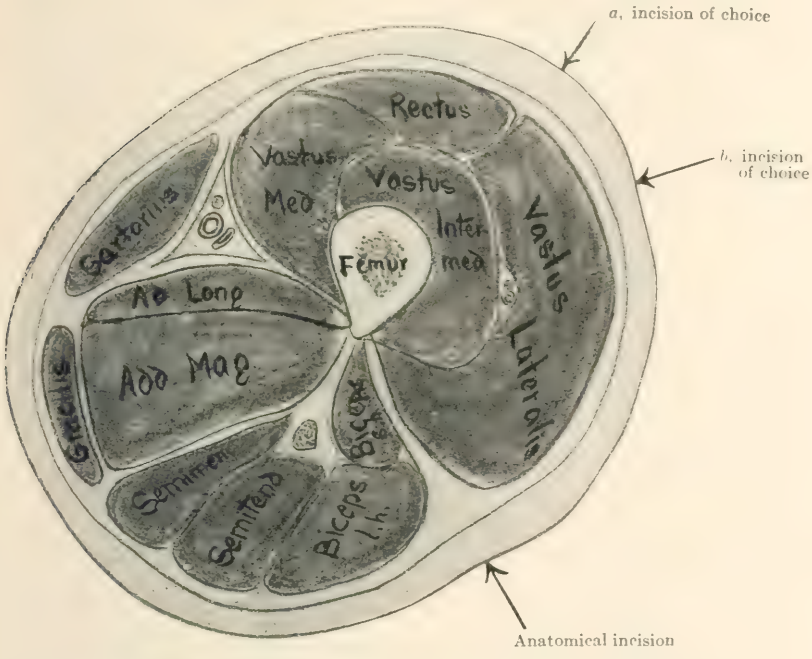

FIG. 23.—Represents a transverse section of the thigh about the middle of Hunter's canal. The shaft of the femur is seen to be deeply embedded in muscles. The incisions of choice are shown by the arrows marked *a* and *b*, the former passing between the rectus femoris and the vastus lateralis, the latter passing through the substance of the vastus lateralis. In either case the vastus intermedius will be divided before the bone is reached. The "anatomical incision" is shown by an arrow. It passes in this situation between the vastus lateralis and the short head of the biceps cruris. It is evident that this incision is excellently placed for drainage.

femur is invested. It will be seen that the femur cannot be exposed without dividing the fibers of the vastus intermedius. If the incision passes medial to the rectus femoris (a very undesirable route) it might be possible to separate the rectus femoris

and the vastus medialis from one another. If the incision passes lateral to the rectus femoris that muscle could be separated from the vastus lateralis (arrow *a*). In either case the vastus inter-

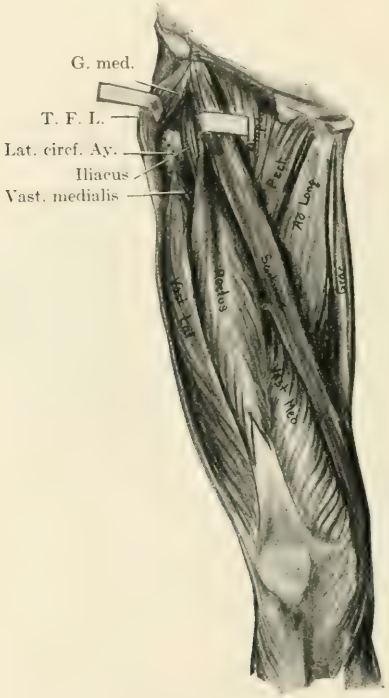

FIG. 24.—Represents a dissection of the muscles on the anterior surface of the femur. At the upper end the dissection has been carried deeply so as to show the steps of an operation to expose the upper end of the femur below the anterior intratrochanteric line and a part of the capsule of the joint distal and lateral to the iliacus muscle. The ascending branch of the lateral circumflex artery is seen crossing the deep part of the wound. The interval between the rectus femoris and vastus lateralis is well shown. The nerve supply to the vastus lateralis enters its medial surface near the edge at the level of the middle of the thigh. The nerves are not shown in the figure. (Original dissection.)

medius would require division before the bone could be exposed. As a matter of fact the vastus lateralis cannot be separated to any great extent from the rectus femoris except in the lower

third of the thigh. The edges of the muscles fuse with one another at the junction of the upper three-fourths with the lower fourth and would require careful separation. At the level of the middle of the thigh the nerve trunks enter the vastus lateralis and bind it down. Careful examination of the point of entry of the nerves supplying the vastus lateralis shows that they spread out like the leaves of a fan. Those supplying the middle of the muscle enter it transversely, whereas those passing to the extreme ends are very oblique. A lateral vertical incision opposite the middle of the muscle would cut the nerves passing transversely but would not injure those passing obliquely to the upper and lower ends of the muscle. As the middle of the muscle is firmly held in place by its nerves, lesions of the middle third of the bone requiring a long incision would be better dealt with by a laterally placed vertical incision through the vastus lateralis. (The line of the incision is shown by the arrow *b* in Fig. 23.)

From the foregoing description of the anatomical arrangement of the muscles covering the shaft of the femur we may conclude that the bone can be exposed safely by the following incisions:

(*a*) By an incision passing between the contiguous edges of the rectus femoris and the vastus lateralis, along a line drawn from the anterior superior spine to the lateral border of the patella. This route is available from a point just below the middle of the thigh (where the nerves enter the vastus lateralis) to the level of the upper limit of the synovial pouch of the knee-joint. After retraction of these muscles the vastus intermedius would be divided down to the bone.

(*b*) By a vertical incision beginning at the lateral epicondyle and extending proximally parallel to the shaft of the bone. The distal fourth or third of the bone could be exposed by this route (see description of the distal end of the femur). Both vastus lateralis and vastus intermedius would be divided.

(*c*) By an incision on the antero-external aspect of the thigh along a line drawn from the middle of the great trochanter to the outer border of the patella. This would be applicable to the

upper two-thirds or even the upper three-quarters of the thigh. In its proximal fourth it would divide fascia lata and vastus lateralis only. In its distal half it would divide both vastus lateralis and vastus intermedius. There is still another route by which the shaft of the bone can be reached, namely, along the lateral intermuscular septum (arrow *C* in Fig. 23). The dissection would pass between the vastus lateralis and the short head of the biceps cruris distally and the vastus lateralis and the insertion of the gluteus maximus proximally. It would expose the posterolateral aspect of the bone corresponding to the outer lip of the linea aspera and its upper and outer and lower and outer branches. It is perfectly feasible in the dissecting room, but it has two serious drawbacks from a practical standpoint: (1) it would entail an incision on the posterior aspect of the thigh which would necessitate giving the anesthetic in a prone position and would leave a wound difficult of access during convalescence, although placed in a satisfactory position as to drainage, and (2) it would pass across the course of a number of branches from the perforating arteries on their way transversely across the femur to supply the vastus lateralis. It would be next to impossible to avoid injuring these vessels which would be hard to secure.

3. *Proximal Extremity.* The proximal extremity of the femur consists of the head, neck and the trochanters. The entire head and the greater part of the neck are within the capsule of the hip-joint. The synovial membrane is reflected on to the anterior surface of the neck at the level of the linea intertrochanterica; on the posterior surface of the neck the line of reflexion is about midway between the crista intertrochanterica and the margin of the head. Thus almost all the anterior surface of the neck is intracapsular, but only the proximal half of the posterior surface. The epiphysis of the head rests like a cap on the upper extremity of the neck. It is entirely within the capsule of the hip-joint (Fig. 26). The epiphysis of the great trochanter lies on the upper and outer surface of the shaft. It is entirely extracapsular. A third epiphysis is seen in the small trochanter. During the growth of the shaft the neck of the bone develops

in an upward direction, and carrying the head on its apex thrusts itself between the centers of ossification of the great and lesser trochanter. A study of the different views of the proximal end of the femur in Fig. 25 will show the muscular insertions around the line of the synovial reflexion and attachment of capsular

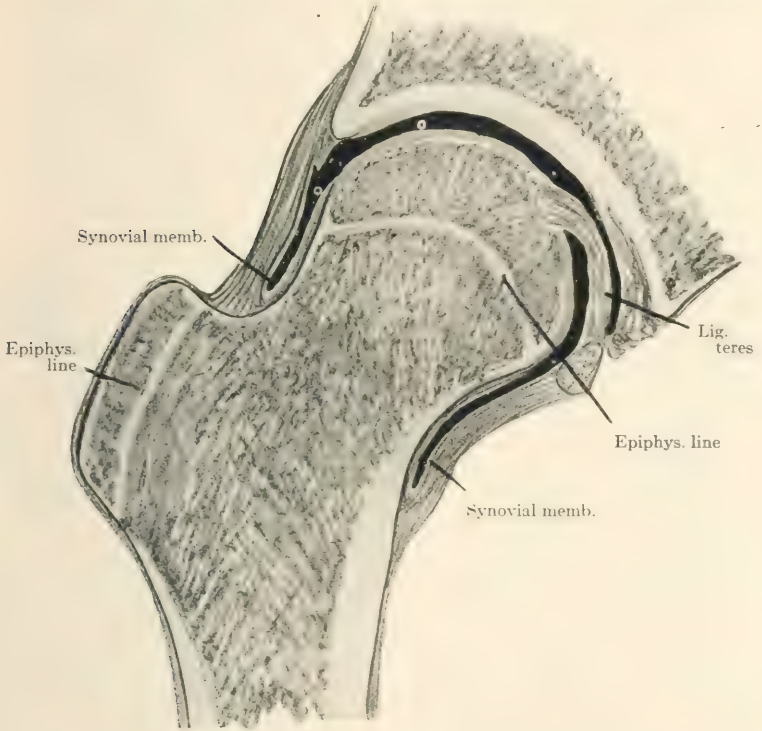

FIG. 25.—Represents a section through the acetabulum and hip-joint. The outline of the joint cavity is clearly shown. The epiphysis of the head is seen to lie entirely within, that of the greater trochanter entirely without the joint. The neck of the femur is seen to be continuous with the shaft. The epiphysis of the lesser trochanter is not shown.

ligament. It will be seen that every surface of the head and neck is closely invested by muscles which arise from the pelvis and pass over the joint on the way to their insertions into the trochanters and the contiguous parts of the shaft of the femur.

The outer surface of the great trochanter is the most accessible part. It can be exposed by a vertical incision through the strong fascia lata into which the gluteus maximus is inserted. If the fascial edges are retracted the bursa between the gluteus maximus and the side of the trochanter is opened and the whole outer surface of the trochanter exposed. If the vertical incision is carried down to bone it will divide the insertion of the gluteus medius at its upper part and the origin of the vastus lateralis

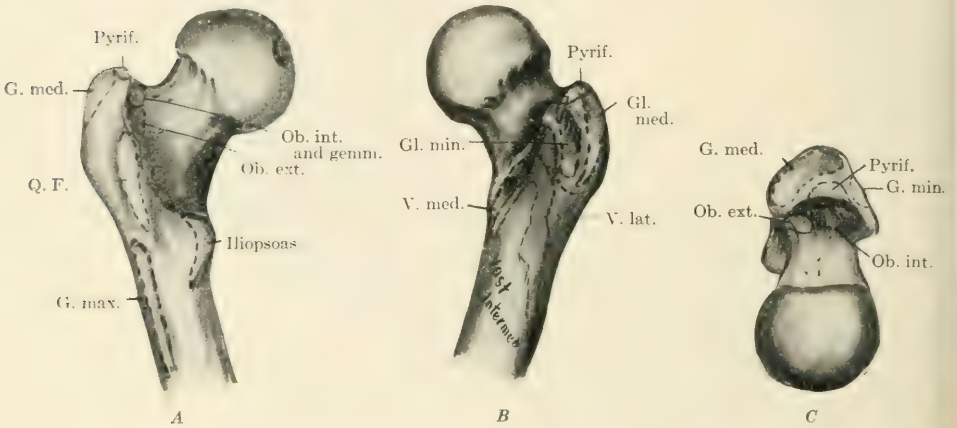

FIG. 26.—Represents three views of the proximal end of the femur. *A* is a posterior view. In it the crista intertrochanterica stands out in relief. *B* is an anterior view. Note the anterior intertrochanteric line which corresponds to that of the reflexion of the synovial membrane. Also note the clustering of the attachments of the vasti and gluteus minimus on the part of the shaft distal to this line. The area of bone distal and medial to the insertion of the gluteus minimus insertion is exposed in the treatment of osteomyelitis of the upper end of the diaphysis. *C* is a view of the upper aspect of the head, neck and trochanter.

below. By peeling these muscles off the bone the whole outer surface of the trochanter major and the upper part of the shaft can be exposed (Fig. 26, *B*).

The posterior surface of the neck is so deeply situated as to be practically inaccessible. A study of the posterior aspect of the bone in Fig. 26, *A* will show that it is covered closely by the pyriformis, both obturators, the gemelli and the quadratus

femoris. Superficial to these muscles the fleshy mass of the gluteus maximus lies. Anatomically it could be exposed by splitting the fibers of the gluteus maximus along the line of an incision passing from the posterior inferior spine of the ilium to the upper part of the trochanter major and thence downward through the fascia lata for about two inches. After retracting the edges of the gluteus maximus the sciatic nerve would come into view as it passed distally over the obturator internus, gemelli, obturator externus and the quadratus femoris. The pyriformis muscle from under cover of which the sciatic nerve emerges would serve as a rallying point. By retracting this muscle upward and the gemelli downward, or, better still, separating them from their insertions and peeling them toward their origins, the posterior aspect of the neck of the femur could be exposed. The whole procedure is very difficult and the route has little to recommend it. The *anterior surface of the neck of the femur* and that of the trochanter major can be studied in Fig. 26, *B*. The gluteus minimus is attached to a large area on the anterior surface of the great trochanter, but as the muscle sweeps from the back to reach its insertion only a small portion of it lies on the anterior part of the capsule of the hip-joint. The front of the capsule is covered by the iliopsoas, the lateral edge of which (iliacus) lies practically parallel with the anterior intertrochanteric line. The contiguous edges of the gluteus minimus and the iliacus are not in contact, as often stated. A triangular interval exists between them with its apex at the insertion of the gluteus minimus and its base above and lateral. The joint can be opened with safety in this interval by cutting through the anterior part of the capsule along the lateral border of the iliacus. If it is necessary to expose the anterior surface of the shaft of the femur below this point the origins of the vastus lateralis, vastus medialis and vastus intermedius can be peeled from the bone. This region can be exposed by an incision from in front, which has been used frequently under various names (Barker's, Lücke's, Hueter's anterior incision) for drainage and excision of the hip-joint. It is almost perfect from an anatomical and physiological standpoint. It passes between muscles with-

out dividing them and passes between the muscles supplied by the gluteal nerve (sacral plexus) and those supplied by the femoral (lumbar plexus). It gives by far the most extensive exposure of the diseased area in cases of acute osteomyelitis of the upper end of the shaft of the femur.

The steps of the dissection are as follows (Fig. 24):

The external incision (the anterior oblique) begins at the anterosuperior spine of the ilium and passes downward and inward parallel with the outer border of the sartorius muscle. The deep fascia is opened between the sartorius and the tensor fasciæ latæ. The sartorius is retracted medially and the tensor laterally. The rectus femoris now comes into view. This is retracted to the medial side. The following structures are now exposed: At the upper end of the wound the iliacus muscle medially and the gluteus medius laterally. If the gluteus medius be retracted laterally the insertion of the gluteus minimus will come into view. Between the minimus and iliacus the triangular interval referred to previously. Distal to the insertion of the gluteus minimus lies the upper part of the origin of the vastus lateralis and internal to this the vastus intermedius and medialis. Crossing the vasti somewhat obliquely is a branch of the lateral circumflex artery. This is often seen as a large trunk which divides at about the level of the base of the trochanter into (1) an ascending branch which passes over the vastus lateralis and enters the borders of the glutei muscles, and (2) a transverse branch which runs over the vastus intermedius and ends under cover of the vastus lateralis which it supplies. The main arterial trunk or its branches should be retracted or ligatured and divided. If the hip-joint is to be opened and explored the capsule is divided along the lower and lateral border of the iliacus muscle, between it and the gluteus minimus. If, on the other hand, the object is to reach the upper end of the shaft and to remove disease from the neck of the femur without opening the hip-joint the origins of the vasti are peeled off the bone to the desired extent and the insertion of the gluteus minimus detached to obtain sufficient room. The dissection shown in Fig. 24 will fully repay careful study.

Recapitulation of Routes of Choice

The Tibia. 1. The route of choice is along the line of its subcutaneous surface from the medial tuberosity proximally to the tip of the medial malleolus distally.

2. Along the line of the medial border of the tendo Achillis and the flexor pollicis longus to expose the posterior surface of the distal end of the shaft for tendon implantation and fixation.

3. Along the line of the lateral border of the tibialis anterior to expose the anterior surface of the distal end of the shaft for tendon implantation and fixation.

The Fibula 1. Along the line of the subcutaneous surface of the lower fourth of the shaft and the lateral malleolus.

2. Along the posterior peroneal septum for the upper three-quarters of the shaft.

The Femur. 1. Vertically upward from the lateral and medial epicondyles for the lower epiphysis and the lower quarter of the shaft.

2. An anterolateral incision, along a line drawn from the anterior superior spine to the lateral edge of the patella, passing lateral to the rectus femoris for a small area at the junction of the middle and lower thirds of the shaft (Fig. 23, *a*).

3. An external incision for the upper three-quarters of the shaft along a line drawn from the tip of the trochanter major to the outer border of the patella (Fig. 23, *b*).

4. Between the vastus lateralis in front and the short head of the biceps and the insertion of the gluteus maximus behind, along a line drawn from the posterior edge of the trochanter major proximally to the posterior border of the lateral condyle distally (Fig. 23, *c*).

5. Along the line of a medial incision extending vertically upward from the adductor tubercle to expose the posterior surface of the lower fourth of the shaft.

6. The anterior oblique incision lateral to the line of the upper end of the sartorius muscle for the exposure of the hip-joint, the neck of the femur and the upper part of shaft.

DISCUSSION ON THE PAPERS OF DRS. DOWD AND THOMPSON

Dr. William L. Estes, South Bethlehem:

I will testify to the value of Dr. Dowd's suggestion because of the difficulties I have experienced in replacing and holding these fractures. I believe his suggestion has a distinct value in selected cases.

Dr. Charles N. Dowd, New York City:

We cannot absolutely state the ultimate result in this case, but I can say that I have seen the patient within a week and he walks on this foot fairly well. He limps a little, does not use a cane much, has motion of dorsal flexion to 80 degrees, of plantar flexion to 105 degrees —that is, he has 25 degrees of motion. This is sufficient for ordinary walking. The strength in his calf muscles is returning satisfactorily. Since two and a half months from the time of his accident, which was on December 28, he has been able to attend regularly to his business. He is very much better at this period than we could have expected him to be if we had permitted the calf muscles to pull the os calcis backward and upward.

THE TRAUMATIC ABDOMEN

By JOHN B. DEAVER, M.D.
PHILADELPHIA, PA.

The stimulation to traumatic surgery brought about by the present war has extended to all branches of surgery, but it is essentially apparent in the field of abdominal work, for it is only exceptionally that the abdominal surgeon in civil life has the opportunity of extensive observation of this class of traumatism.

It is generally conceded, however, that there is distinction without difference in civil and war surgery of the abdomen. The same principles apply to both, paramount among them being early diagnosis and prompt treatment.

The apparently easy cases are generally the most difficult to diagnose. After the initial shock a reaction often sets in, which proves as deceptive to the patient as it is to the surgeon in attendance. Prostration, pallor, anxious facies, thirst, cold, exquisite pain on moving the body, limited abdominal movement on respiration, rapid pulse of low tension, rigidity, dulness in the flanks, vomiting—these are symptoms that leave little doubt of some visceral lesion; but often the picture is not so clear in spite of the presence of serious intra-abdominal injury. And again experience, especially with small particles of shell from an exploding bomb, has shown that one must be careful about making a negative diagnosis. The wound is often so small and insignificant while the velocity of the missile has been very great, that it sometimes takes actual "strength of mind" to explore the abdomen, although the symptoms point to the probability of visceral injury; oftentimes, too, a man hit in the abdomen is quite unconscious of the fact that the intestines are prolapsed.

In the early part of this war non-intervention was practically the rule in the treatment of abdominal injuries and the wounded were kept, in so far as this was feasible, as close as possible to the spot where the wound was received. With the perfection of the hospital and nursing service, a complete reversal of this principle was adopted, especially with the establishment of opportunity for prompt surgical attention reasonably close to the front, so important in this class of cases the mortality of which increases rapidly if treatment is delayed beyond twenty-four hours after the receipt of the wound. While operation is now considered the only chance of recovery in the vast majority of cases, though it sometimes represents only a minimum chance, there is a small percentage in which expectant treatment may be justified. These include mainly contour wounds and cases in which the projectile has apparently not traversed the abdomen but has been arrested in the immediate vicinity of the peritoneum, causing only reflex peritoneal reaction; abdominal wounds without visceral or vascular lesions, rare though not unknown; and wounds causing unimportant hemorrhage, as in perforation of a solid viscus, such as the liver, spleen or kidneys; and finally a few actual perforations fortunately small of the ascending or descending colon by the development of circumscribed peritonitis and a fistula.

With the exception of a few individual so-called "abstentionists" surgeons among our allies have ranged themselves with the "operationists," and to them an abdominal injury means incise, look for the damage and treat it. Even advanced cases of peritonitis and occasionally a pulseless patient have profited by operation when *abstention* would have meant certain death. The dictum seems to be: operate, operate early, operate as near to the front as possible, and make your operation complete if possible.

Shock may be combated by the usual means, but too much time should not be lost in this measure. Symptoms of shock often do not appear during the first two or three hours, except in cases of profuse hemorrhage, or of effusion of intestinal contents into the abdominal cavity, so that shock does not necessarily

contraindicate operation. Moreover, the patients are usually young men whose physical resistance has been developed to a high pitch so that what might be venturesome in civil life proves less so in war conditions.

Interesting studies are being made on the subject of shock and hemorrhage. The importance of the question is evidenced by the appointment of special committees to investigate and coördinate the results of the studies made. From the reports that have thus far been published we gather that, although the underlying etiological factor in the production of symptoms of shock has not yet been determined, existing observations as to blood-pressure and physical changes in the blood have been confirmed and new ones have been brought forth, several groups of cases having been studied almost from the moment of being injured and at various stages before reaching the operating theatre as well as after operation.

Without in any way reflecting upon the value and the importance of these studies, I venture to question their practicability at this time, for the traumatic abdomen. Abdominal cases are emergency cases and there is rarely time, nor, I should think, the proper equipment, at the front for making these studies, necessary to decide whether a man is suffering from shock or hemorrhage or both, nor at the present time with the shortage of laboratory assistants in civil hospitals is it always possible to have such studies made.

Differentiation of shock and hemorrhage is a very delicate one. It is to be anticipated that the studies of the research committees, already referred to, will furnish very definite conclusions in this regard. The leukocyte count which is increased in hemorrhage and is not apt to be affected by shock often throws some light on the subject. But with the means at present at our disposal much depends on the intuition of the experienced surgeon who more often than not makes the differentiation correctly.

In the diagnosis of a suspected abdominal lesion pain is of little aid. It varies in degree and there is apparently no direct relationship between its intensity and the extent of the injury. Pulse

and the degree of abdominal rigidity are of importance. A man with a pulse of more than 110° is not usually able to withstand prolonged anesthesia and requires suitable treatment before operation is undertaken. Hemorrhage should always be suspected and then it is the state of the pulse that is often the deciding factor for or against intervention. Abdominal rigidity varies from generalized rigidity over the entire abdomen to a small localized area. The latter often occurs in late cases where a lateral wound has involved only the colon, and a fecal fistula or walled-off fecal abscess has formed. The absence of rigidity is now generally recognized as an unfavorable prognostic sign, since it is usually associated with extensive lacerating lesions of the small and sometimes the large intestine and usually is seen in cases that come under observation from ten to twelve hours after being wounded.

Vomiting, though it forms part of the history of nearly every case of abdominal injury, is not a constant feature, in fact, it is often a prominent symptom where there is no visceral lesion. The same inconstancy characterizes hematemesis and melena; when present they are valuable diagnostic signs, but their absence does not necessarily indicate the absence of perforation of a viscus.

Nor is the site of the wound an unfailing indication as to the involvement or otherwise of the abdominal cavity. A foreign body may enter almost any region of the body and traverse or lodge in the abdomen. The records of the present war injuries of the abdomen contain a surprisingly large percentage of cases in which a bullet entering the buttock has caused lesions of the cecum or the pelvic colon, or where involvement of the kidneys, colon, liver and spleen has resulted from a foreign body entering behind a line extending from the mid-axilla to the anterior superior spinous process of the ilium.

A valuable diagnostic point is the consideration of the entrance and the exit wounds, where both are present, and the course and direction of the track, that is to say, the plane of abdominal involvement and the structures that may have been traversed.

Intestinal injury, for example, may be taken practically for granted where the track of the bullet extends anteroposteriorly in the center of the abdomen or where its course is transverse between the costal arch and the crests of the ilia. This type of injury is generally fatal, although a few exceptional recoveries have been reported. Intestinal injury likewise practically always results from contused wounds caused by localized violence, such as a sudden blow full on the abdomen or a fall from a height, or a weight falling on the abdomen.

Abdominal injuries, I repeat, are to all intents and purposes emergency cases and there is little time for elaborate preparation before the patient reaches the operating table. The removal of the clothing, emptying of the bladder, washing the skin, preferably with a carbolic lotion or iodine, is about all that can be done in the majority of instances. Morphin and atropin are given hypodermically, and if possible one hour before the anesthetic, preferably ether, is administered. Satisfactory results have been obtained with intravenous injections of bicarbonate of soda, just before the anesthetic is given. The bicarbonate of soda not only counteracts the acidosis which is nearly always present, but at the same time reduces the concentration and the viscosity of the blood.

The incision is a matter of judgment on the part of the surgeon and will also depend on the suspected viscera involved, irrespective of the site of the wound. As a rule, however, a median or paramedian longitudinal incision is selected and should be ample so as to allow free access to the cavity, which in turn means rapid work. The value of *x*-ray demonstration of the location of the foreign body is well illustrated in those cases with only a single wound of entrance. It avoids unnecessary exploration of the entire abdomen, when a bullet has, for example, lodged in the loin, the only injury being a lesion of the colon to its peritoneal reflection; in which case the incision is made accordingly.

Opinions differ as to the value of drainage to the pelvis and the flanks. Some surgeons find nothing to recommend it, and they limit drainage to the use of a small drain carried down to the line

of the sutured bowel, and thus provide a local track in case of leakage. Other surgeons drain in case of profuse hemorrhage where all oozing cannot be arrested, the best use of the tube in these instances being as a conductor for a tampon; also for possible leakage in wounds of the hollow viscera and when septic material has been extravasated and in cases requiring tamponage and temporary suture; also in stomach and colon lesions where there was much free blood in belly, or where, as often occurs in late cases, a free serous effusion had collected in the abdomen. It should be remembered that the peritoneum does its best work when unhampered, which means limited drainage, if any.

Lavage of the abdominal cavity is not generally advocated. Ether has been almost altogether abandoned for this purpose; satisfactory results with the use of warm serum have been reported but saline is the medium of choice. Personally I do not practice lavage, as a rule.

As to the involvement of one or the other viscus, it appears that in war injuries of the abdomen the small intestine is the most frequently injured. The mucous membrane from the one or several perforations prolapses through the rent in the form of rosettes, the eversion being due to contraction of the longitudinal coat. The damage is local, the mucous membrane being normal up to the rent. It is the multiplicity rather than the danger of sepsis that lends these wounds their serious character. Suture is the proper method of treating them; resection being reserved for cases with numerous perforations close together. Post-mortem observation thus far has shown no evidence of spontaneous healing of wounds of the small intestines.

The large intestine when wounded usually presents only a single tear or perforation rather than a complete section of the gut. The wounds of this viscus show a greater tendency to sepsis and sloughing than those of the small intestines. They are often extra-peritoneal, a notable feature being the extent of bruised surface, as seen in the collection of blood between the peritoneal and the external walls.

Colon wounds are characterized by their tendency to localiza-

tion. Therefore if they come to operation later than twenty-four hours after injury it is advisable to enlarge the original wound with the idea that infection is localizing. If seen before that time a separate incision is the better procedure. Colotomy at the site of injury is required when the wound is extensive; otherwise suture reinforced by omental graft seems to be the chosen method. Suture combined with proximal colotomy has not found the extensive application that was expected. It proved to be superfluous, inasmuch as, the tissues being already infected, its primary object of limiting infection had already been forestalled, besides which the extra opening in the bowel is undesirable.

Wounds of the stomach are usually associated with injury to other abdominal viscera and often with lesions of the thorax. Peritonitis following a stomach wound usually develops slowly and runs a subacute course, except where bile has escaped from the stomach. Simultaneous perforation of the anterior and posterior wall often takes place, and as the latter is easily overlooked, careful exploration of the entire stomach through the intercolo-epiploic route is most important. It seems that suture is the preferred method of dealing with perforating gunshot wounds of the stomach. Gastro-enterostomy, with or without previous suture, is resorted to only for very extensive lesions or when the antrum or the duodenum is involved or where there is a narrowing of the stomach.

Wounds of the rectum, when extraperitoneal, are treated in the usual manner by establishing drainage after the wound has been opened up; and when intraperitoneal, by suture followed in certain cases by colotomy. If possible the colotomy is made in the transverse colon, this opening being more easily controlled and cleansed facilitates subsequent restoration and closing of the bowel. Also in the event of secondary operation for the repair of the rectum the pelvic colon can be mobilized and brought down to the injured part.

Bladder wounds are fortunately rare, for their mortality is very high. Extraperitoneal injury, indicated usually by hemorrhage into the bladder, may be treated by catheterization or

by perineal section; intraperitoneal injury, however, the more serious of the two, demands immediate operation.

Of the solid viscera the liver is the most frequently involved, and is at the same time the viscus which most often recovers without operation. Operation is indicated where there is evidence of profuse hemorrhage, and generally consists of inspection, plugging and drainage.

Wounds of the spleen *per se* usually require splenectomy. They generally occur as complications of other lesions. This is also true in the rare instances of wounds of the pancreas. The prognosis of pancreatic injury is bad, hemorrhage is generally very severe, and treatment is mainly directed to controlling hemorrhage by suture or gauze packing and lumbar incision.

Post-operative treatment of the traumatic abdomen does not essentially differ from the regimen in use for other abdominal operations. In fact, this necessarily rapid and cursory survey seems to bear out the statement that there is little difference in civil and war surgery of the traumatic abdomen. The great advantage gained from war experiences is the removal of any hesitancy in exploring the abdomen, and with it the reduction of about 10 per cent. in the mortality in this type of injury. This alone justifies the prevalent practice of early and thorough exploration and operation, although, if carried to its logical conclusion, it represents a certain risk of losing some cases that might have recovered without operation.

DISCUSSION

Dr. William J. Mayo, Rochester, Minn.:

First, with regard to the fatal improvement of the reaction period: I so term it because I know of nothing that has caused the loss of more lives than the improvement that follows a few hours after the first shock of an intra-abdominal injury and leads the inexperienced to believe that the patient is better while the phase of contamination passes into septic peritonitis before an operation is performed. If the patient is otherwise in good condition the abdomen should be opened in all suspected cases of visceral injury, as the risk to the patient is small; if there is no injury, everybody will be happy; if there is an injury, the patient will have a chance for recovery.

With regard to drainage, we are getting further and further away from its use. We often speak of drainage when we mean tamponage; or when we desire to quarantine an infected area and cause a canal to form, connecting with the surface. In the stage of contamination, drainage is apt to be harmful and in general peritonitis is of little use except to maintain connection between a localized area and the surface. After intestinal suturing, drainage frequently causes a fistula to form and in any case may permit of mixed infection. When in doubt, do not drain.

I think these matters are extremely important, and I should dislike to have any opinion go out from this Association that did not take a stand for the only thing justifiable in my estimation in such cases, and that is, the early opening of the abdomen in suspected visceral injury.

Dr. Herbert A. Bruce, Toronto, Canada:

I agree with Dr. Mayo with regard to drainage. We only drain when the posterior peritoneal space is involved, and then by puncture from behind. We simply mop out the abdomen, suture the wounds and perforations in the intestines and close the abdomen. Every abdomen at the Front is opened and the results are about 50 per cent. recovery for those who are gotten early in our advanced operating centers. Since March 21, in consequence of having to take the wounded a greater distance to the rear before operative intervention, the mortality has increased to 80 per cent., which clearly shows the necessity of early operation.

Dr. Edward W. Archibald, Montreal, Canada:

I had the opportunity of handling some 50 cases of abdominal wounds at a Front Line station. The principles which I formulated

from this experience have been very well expressed by Dr. Deaver, whose paper epitomizes our knowledge at the present time. There are a few points I would like to mention: Wounds of the liver are now rarely operated on unless giving signs of extreme hemorrhage, which is not frequent. Combined wounds of the chest and abdomen are not operated on now, although we used to do so, because they give an extremely high mortality. If you treat first the chest wound, close the open pneumothorax, aspirate an infected pneumothorax, and then later, say after a day or so, treat the abdomen, you get better results. As regards operating in shock: I think that here lies the fundamental difference between civilian and war work. We get "traumatic abdomens" in civil surgery, but not the same shock. The difference in mortality when the cases travel long distances is due rather to the longer and harder journey than to the lapse of time. Shock is the fundamental fact in the mortality of the traumatic abdomen in the war. If the patient's blood-pressure is below 75 mm. there is little use in operating. If you have in addition other signs of profound shock, you will rarely save the patient. Personally, I believe that early operation in badly shocked cases is a mistake; one should wait for a while. As to the mortality, one must recognize that it must remain high in war. The original recovery rate was between 30 and 40 per cent.; we thought we were doing well with 40 per cent. recoveries, and when one surgeon got 60 per cent. we thought it amazing.

Dr. Randolph Winslow, Baltimore:

I have had quite a large experience in gunshot wounds of the abdomen, but it cannot be compared to that of the men who have been to the Front. Dr. Mayo and Dr. Bruce have stated that they are giving up drainage of the abdomen. I recently had a man, with a perforated duodenal ulcer, and when operated the abdomen was full of fluid down to the pelvis. Would any of you consider that a proper case to treat without drainage? So, in gunshot wounds of the abdomen, of which I have had some fifty cases, it seems to me that when there is fecal contamination of the peritoneum, particularly if involving an extensive area, drainage should be used.

Dr. William L. Estes, South Bethlehem:

I think there can be no doubt about the treatment of the perforating wound, but there is a class of wounds, with which we meet in civil life, which is a great bother. These are the injuries to the abdomen from accidents of falling or from automobile accidents, etc., when there is absolutely nothing on the outside of the abdomen to indicate the loca-

tion or extent of the injury. In such cases one must be extremely careful not to be deceived by the reactionary period occurring a few hours after the accident, as mentioned by Dr. Mayo. Time and time again I have been deceived by it and later opening the abdomen have found extensive lacerations. An extremely common laceration is that of the mesenteries near their attachment to the liver, to the spleen or to the kidney; another common laceration is a curious one of the jejunum at Treich's ligament. I have found time and time again, after having passed over every part of the abdomen, the gut torn one-quarter or one-third across at this point. When there are fixed bands to the movable viscera these lacerations are apt to occur.

Dr. John T. Bottomley, Boston:

Some years ago my former chief, Dr. John C. Munro, called attention to the danger of delaying too long the operative treatment of traumatic abdominal cases in which there was any doubt as to whether or not visceral injury had taken place. It has been my custom to rely on the pulse-rate as my guide in these cases; a chart is immediately started on which is indicated every half-hour the pulse-rate; a gradually rising pulse is an indication for a speedy operation; on the other hand, an unchanging pulse-rate or a falling one denotes that operative interference is not necessary. In many cases laparotomy must be a purely exploratory measure, but there is no instance in the field of abdominal surgery in which it possesses possibilities of greater value.

POST-OPERATIVE THORACIC DRAINAGE

By WILLY MEYER, M.D.
NEW YORK

It is natural that in the course of operations within the thorax, same as in other parts of the body, conditions arise, or such pathologic affections are encountered, that drainage becomes indicated. Yet, for quite a time it was not carried out on indication, but, on the contrary, strongly advised against, owing to the inevitably resulting, often fatal, pneumothorax.

Right here it should be stated that pathologic affections of the pleural sac as such—primarily among them "empyema" —are excluded from this discussion. The treatment of purulent inflammations of the pleura occupies a place of its own in operative surgery, and does not, strictly speaking, belong to what is generally designated as "thoracic surgery." The latter term refers to surgical attacks upon organs situated within the thorax, *beyond* the pleural sac, though the latter, whether in its normal physiological, uninflamed, "virgin" condition, or, chronically inflamed and more or less adherent to the lung, but still representing the greater portion of a free pleural cavity, has to be traversed. In other words, the class of thoracic cases considered in this paper as requiring subsequent drainage comprise operations upon the lungs and bronchi, the esophagus, heart with aorta and pulmonary artery, and mediastina, as also upon organs of the abdominal cavity if attacked through chest and diaphragm, *i. e.*, cases of transthoracic laparotomy.

At our hospital the problem of avoiding a post-operative acute

pneumothorax as the result of drainage was solved in the following manner:[1]

After hermetically closing the thoracic incision and providing for free drainage of the chest at the most dependent place of the pleural cavity, these patients were placed under differential air pressure (first case, May, 1911). 1. By this procedure their lungs were kept distended. That is to say, before closing the thoracic incision by means of layer sutures, a stab was made in the ninth or tenth intercostal space and within the scapular line, long enough to allow two split rubber tubes and a cigarette drain to pass through it easily. The intercostal stab wound—dressed with a split piece of sterile gauze—plus projecting drainage tube ends, was covered with a large piece of sterilized rubber dam. To hold the latter in place, its borders were made to adhere to a layer of zinc ointment which had been liberally spread over the immediate neighborhood of the drainage hole. When the patient was allowed to breathe again under normal atmospheric air pressure—usually after fifteen to eighteen hours—the piece of rubber dam performed, I believe, a very important task: It acted as a valve, allowing secretions to escape from within outward into the dressing, but preventing air from entering the thorax along the drains.

The method proved eminently successful, provided the patients were not removed from the apparatus too early and the rubber dam had been properly placed. But it was cumbersome and expensive, two special nurses being required to be on duty simultaneously during the first twenty-four hours and then alternately for the second twenty-four hours, during which latter the patient was placed in one of the so-called "recovery rooms" of the thoracic pavilion of the hospital, in order to give us an opportunity to determine whether he could be safely moved back, either to the ward or his private room.

From the operating table the patient was conveyed to a bed specially constructed for the purpose (Fig. 1.) As will be seen,

[1] Willy Meyer: "On Drainage after Intrathoracic Operations with Special Reference to the Esophagus." Annals of Surgery, 1912, vol. lvi, p. 100.

its frame has no back and it is of the same height as the opening which allows the patient's head to pass into the positive pressure cabinet (Fig. 2).[1] A nurse is permanently within the latter, while a second one administers to the patient's needs without (Fig. 3). One of the duties of the outside nurse is to reduce the pressure to 1–1½ mm. every half hour in order to avoid overtaxing the heart muscle with the continuous higher air-pressure

FIG. 1.—Special bed for drainage, thirty inches wide. Height corresponds to positive pressure apparatus. Mattress projects above end frames. Large rubber-tired wheels; brake for two.

of 5 to 6 mm. She also is required to carry out artificial respiration with the apparatus at regular intervals, a procedure which represents the best known heart stimulant on a physical basis. Arrangements have been made to carry out the same kind of after-treatment within the negative chamber (Fig. 4), likewise

[1] Annals of Surgery, loc. cit.

for the purpose of avoiding overstrain of the heart muscle. The latter variation has not been tried as yet. Fig. 5 shows a patient in the negative chamber ready for operation. It gives an idea of how a patient should be placed in it with due regard for the contemplated after-treatment, viz.: on his back.

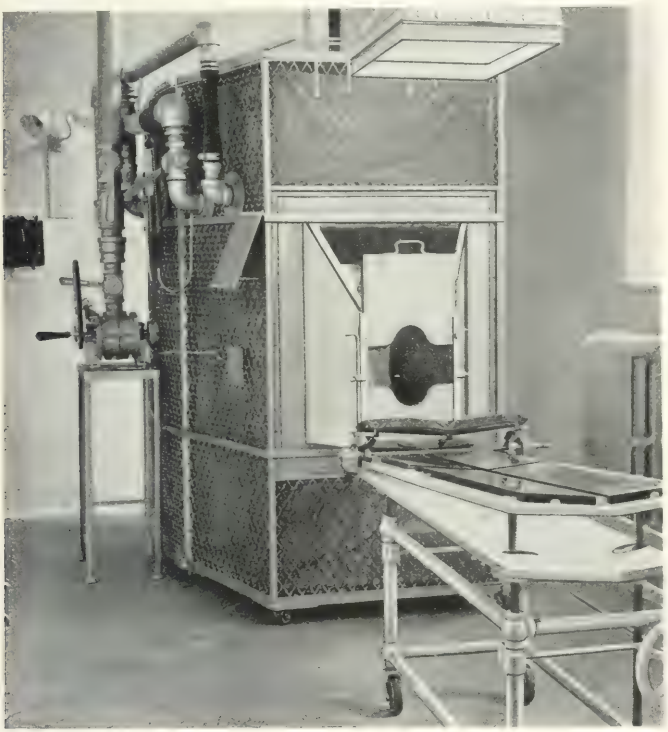

FIG. 2.—Positive pressure cabinet at the thoracic pavilion of the Lenox Hill Hospital. It was photographed with one of the operating tables in front of it.

2. Almost simultaneously with the publication of this mode of draining the thoracic cavity, another method appeared in print, namely, that of Tiegel, then of Dortmund, Germany.[1] He constructed and tested a drainage tube made of flexible metal, which

[1] Centralbl. f. Chir., 1911, No. 10.

carried as a prolongation of its end—within the thorax—a rubber tube. It had a rubber valve at the outer end, covered by a wire frame (Fig. 6). The latter took care of keeping up the action of the valve by holding off the dressing which buried the tube. It was usually left in one angle of the thoracic incision, or introduced

FIG. 3.—Patient in place for after-treatment with free drainage of the pleural cavity under positive pressure. Note the nurse inside the cabinet ready to carry out instructions; outside the patient can undergo any kind of after-treatment which may be deemed advisable.

through a special stab. Tiegel saw satisfactory results from the use of this valve drain. Personally, I have never tested it.

3. Remembering the all-important principle in thoracic operations of simplifying as much as possible the required work, in order not to have this chapter of operative surgery take an exceptional place, and yet always strictly observe the factors of safety,

the author searched for a long time for a method of post-operative thoracic drainage which would not only allow the patient to be returned from the operating room directly to his bed, but at the same time permit of air-tight closure of the wound. Incidentally, the method would of course have to afford security from the occurrence of a post-operative acute pneumothorax.

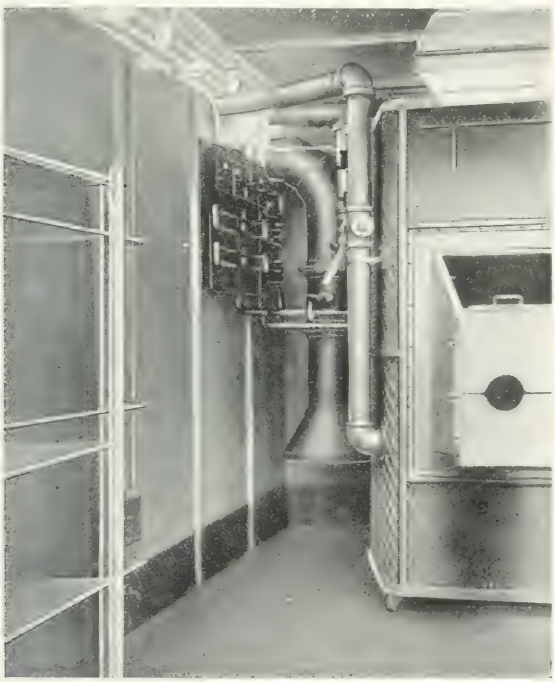

FIG. 4.—A view of the interior of the negative chamber at the pavilion for thoracic surgery, Lenox Hill Hospital, New York, N. Y.

On studying the recent literature with this point in view, the author came across Kenyon's method of draining empyema in children[1] which consists briefly in the following:

After proper local preparation, the aspirating needle proves the presence and location of the pus. It is left in place. Along-

[1] Johnson: Operative Therapeusis, vol. i, p. 242.

side the same a narrow-bladed knife is inserted between it and the upper margin of the rib below, until it penetrates the pleural cavity. A short incision is made, the knife withdrawn and

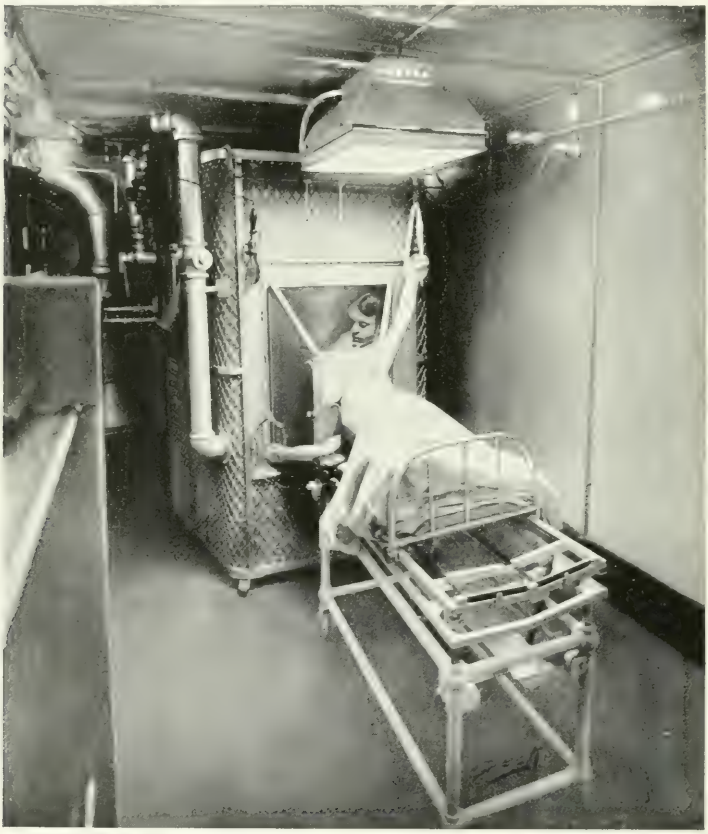

FIG. 5.—Patient ready for an intrathoracic operation in the chamber. The special operating table has been supplied with removable side flanges which widen it sufficiently so that a mattress can be placed upon it for after-treatment under negative pressure. The anesthetist, or nurse, and the patient's head are inside of the positive cabinet which stands within the chamber.

replaced by an artery clamp. After removal of the needle, the branches of the clamp are spread and the drainage tube crowded in. It passes through a button-holed piece of tape which is

fastened to the chest-wall with adhesive plaster and prevents its slipping out, while a rubber cuff over the tube takes care of its not slipping in further. The end of the tube is connected with a bottle underneath the bed same as when draining other cavities of the body. The accompanying illustration, taken from Kenyon's article, nicely brings out the various points in question (Fig. 7).[1]

The author decided to try and adapt this method to the needs of thoracic surgery in operations on organs situated *beyond* the pleural cavity. After repeated conferences with Doctor Kenyon, it was considered best not to make any material change, but to test

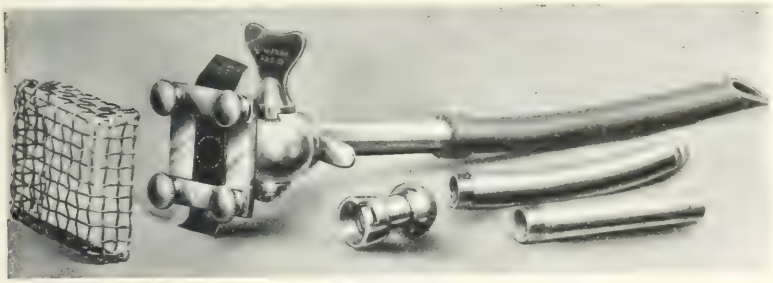

FIG. 6.—Tiegel's thoracic drain.

the essentials of the method at the next opportunity. The latter presented in a case of resection of the esophagus for carcinoma, done at the Post-Graduate Hospital under intratracheal insufflation, on December 17, 1915. As the author desired to drain the bed of the esophagus after resection in the posterior mediastinum, by means of a long cigarette drain, provisions had to be made that the latter could pass through the Kenyon drain. It was

[1] In No. 1 of the Centralbl. f. Chir. of 1916, Schmerz, of von Hacker's clinic in Graz, publishes a new method of treatment of empyema, the principle of which is very similar to that of Kenyon's method, which was published in 1915 and first tried in 1910. Schmerz's procedure is more cumbersome, in so far as he perforates the rib and inserts a rubber drainage tube with v. Hacker's method of stretching the tube over a probe. If the consistency of the contents require a tube of larger size, a portion of rib is resected and a perforated rubber cork with a glass tube fitted in.

therefore decided to make use of a flattened metal tube (with inside fenestra), through which the cigarette drain could be passed; it was fastened at the outer end of the tube by a special arrangement.

The curved incision surrounding the scapula, with division of five ribs at their angle (Torek), was used. As usual, the proximal portion of the esophagus was brought out at the neck and trans-

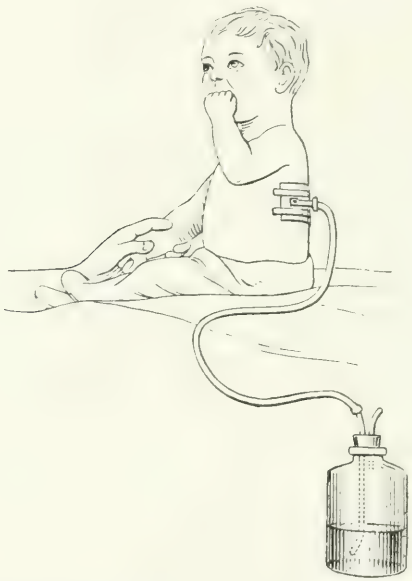

FIG. 7.—Baby suffering from empyema, with Kenyon's drainage started (taken from Kenyon's article.)

planted antethoracically, beneath the skin. Kenyon's drain was placed as in method 1 (see above), viz.: through a special stab in the tenth intercostal space, in the scapular line. The tumor was firmly adherent behind the aortic arch which latter had to be mobilized. During resection it was found that the growth had penetrated beyond the esophageal wall into the posterior mediastinum. Ligation of the vena azygos became necessary. The shock, consequently, was great. The patient lived but a few

hours. However, it was observed to our greatest satisfaction that on raising the head of the bed, the air which had been left behind within the thorax when suturing the incision bubbled out into the water of the bottle placed beneath the bed, synchronously with the patient's respiratory movements, until the lung evidently had become completely expanded. Incidentally, bloody

FIG. 8.—The simple make-up of Kenyon's drain adapted to drainage after thoracic operations beyond the pleural cavity. The center hole in the cork is, of course, somewhat smaller than the circumference of the tube; the latter has to be of good size and of medium elasticity. By putting the tube on the stretch, the cork can be slipped up or down. The latter distends in boiling and then holds the tube less tightly. This point has to be carefully decided before the operation, and matters must be properly adjusted.

secretion was observed to enter the water in the drain bottle in greater quantities. It was distinctly seen in the interposed glass tube how a column of water in the drainage tube that hangs down into the water within the siphon bottle raised and fell with respiration.

The method had stood the test well and it was decided to continue its use.

Quite some time elapsed before the next appropriate case came to hand. For the drainage in this case it was planned, after consultation with Doctor Kenyon, to substitute a rubber tube for the metal tube formerly used, and make it pass through a central hole in a slice of cork, this hole having a slightly smaller diameter than the rubber tube (Fig. 8). Both cork and tube are sterilized by boiling.

Case II.—*Recent case of bronchiectasis of left lower lobe. Incision of free pleural cavity for exploration; closure of the incision and drainage of the chest by means of Kenyon's method. Immediate pneumotomy. Recovery.*

J. L., male, aged thirty-two years. Lung suppuration following pneumonia of left lower lobe in the summer of 1916; sputum often foul; some blood; quantity: 100 to 150 c.c. in twenty-four hours. *X*-rays and bronchoscopy corroborate the diagnosis.

Operation (January 11, 1917).—Pharyngeal insufflation (Doctor Branower). Intercostal incision in seventh interspace, curving upward posteriorly, enters free pleural cavity; hand introduced locates adhesion of lung posteriorly parallel with spine. Aspiration in paravertebral line over the adherent portion, thus made out, finds pus about two inches below surface. It is decided to close the free portion of the pleura with Kenyon's drain in place and then do pneumotomy posteriorly at the same sitting. Aspiration needle withdrawn; its point of entrance marked on skin with knife. Resection of the greater portion of seventh and eighth ribs with excision of the intercostal soft tissues posteriorly over the adherent lung, and ligation of intercostal arteries near the stump of the ribs. Quite some area of lung is thus exposed. Incision in ninth interspace in scapular line down to pleura with operator's second and third left fingers as guide within the pleural cavity; pleura bluntly perforated with dressing forceps, blades spread and Kenyon's drain, the size of middle finger, with lateral hole near its end, introduced for about $2\frac{1}{2}$ inches. Careful suturing of intercostal muscles of fascia and of skin in layers, tightly around the tube, the former tissues with chromicized gut, the skin with silkworm gut; split piece of gauze slipped under cork

and the latter fastened with partially divided strips of 2-inch wide zinc adhesive plaster in such a way that the plaster runs somewhat up on the tube and at the same time holds the cork tightly down to the wound dressing and the surface of the chest. Three such pieces of divided zinc plaster, running in various directions, are put in place over the cork (Fig. 9). They make the drainage tube an absolute unit with the chest wall and that in an air-tight way; outer long end of tube closed with artery

FIG. 9.—The drain in place. In practice the patient rests in a slight Fowler's posture with the shoulder of the drained side supported and the head of the bed raised on blocks as long as the drainage lasts.

clamp. Now intercostal wound sutured in its anterior portion, in part over a short tamponing piece of iodoform gauze, because the pleural incision itself could not be satisfactorily closed by stitches in its entire length; aspirating needle reintroduced at place marked before, now draws principally air into the well-working record syringe, with just a few flakes of pus. Evidently the cavity had been successfully struck again. Alongside the needle the lung is incised with the Paquelin cautery parallel to

spine, viz.: in a perpendicular direction. In considerable depth the cavity is opened, clearly representing an irregular distention of a bronchus. The palpating finger, on widening this bronchus toward the lung hilus, enters with its tip into another communicating cavity. Drainage and tamponade with split rubber tubes and iodoform gauze; lung wound left wide open. Patient returned to bed with pleural drainage started; head of bed raised. Air-bubbles and bloody fluid escape at once.

First twenty-four hours: 100 c.c. of serosanguinolent fluid drained off; slight rise of temperature. Twenty hours after operation suddenly very rapid pulse and respiration; patient restless. Secretion: turbid serum.

Second twenty-four hours: Temperature rising; much cough; controlled by morphin; secretion turbid, contains pus and bacteria which prove to be streptococci. Amount not charted. Diagnosis: Acute suppurative pleurisy.

Third twenty-four hours: Discharge more purulent; 200 c.c. drained off into bottle.

Fourth twenty-four hours: Better; fever dropping.

Fifth twenty-four hours: Further improvement; amount of drainage = 100 c.c.

Sixth day: Drainage = 75 c.c. From now on, slow drying-up. First change of dressing: primary union of chest wound: iodoform gauze tampon removed over pleural incision; the latter has firmly closed. Thoracic drain pulled out for about one inch. It is again secured in place with the adhesive plaster strips.

Seventh day: Small drain inserted to replace large one; out of bed.

Small drain removed on eleventh day after operation; recovery with complete closure of chest wound; no bronchial fistula (Fig. 10).

Comment.—In this case an acute suppurative pleurisy developed under our eyes; threatening at first, it was quickly and successfully overcome by the presence of the large drain in the most dependent spot of the pleural cavity. This proved the great value and necessity of post-operative thoracic drainage, and

greatly strengthened our faith in the efficacy of this method of after-treatment.

FIG. 10.

CASE III.—*Osteosarcoma of ribs; resection of chest-wall; post-operative drainage of chest (Kenyon). Recovery.*

Female, aged fifty-four years; tumor immediately below right breast, involving several ribs in mammary line.

Operation (March 5, 1917).—Intratracheal insufflation (Doctors Sanford and Pickhardt). Formation of a large oval skin-flap with convexity downward, from axillary to middle line, with which right breast is raised. Resection of chest wall within healthy tissue; a rectangular piece, including four ribs, is cut out. Kenyon's drain placed in ninth intercostal space, posteriorly; careful stitching of skin-flap in place. With tube held firmly *in situ*, the lung is blown up before the last skin sutures are tied and the outer end of the tube then firmly clamped, in this way driving out as much air as possible. On raising the head of the bed, after the patient had been returned to the ward, and connecting the drainage tube with the bottle, only bloody fluid was seen to escape, no air bubbles, showing that the lung had been fully blown up. The patient breathed comfortably.

Amount of drainage: First twenty-four hours, 400 c.c.; second twenty-four hours 175 c.c.; third twenty-four hours, 50 c.c. From this day on drainage ceased.

On the fourth day, the adhesive plaster around tube and cork was lifted in part and the tube pulled out about $1\frac{1}{2}$ inches and then refastened, leaving dressing otherwise undisturbed. First change of dressing on seventh day. Primary union of wound. Large drain exchanged for smaller one; patient out of bed. Drain left out entirely two days later (Fig. 11).

FIG. 11.

Comment.—It would likely have been perfectly proper to remove the drain on the fourth day after the operation, when drainage from the chest had ceased. It was kept in place three days longer merely for safety's sake. The substitution of the smaller sized drain for the larger one might then be dispensed with.

Of course, I am well aware that many cases of successful resection of the chest wall, without drainage, are on record. However, the case ran such a normal and undisturbed course and the presence of the drain created so little discomfort, that it might be

wise, for the sake of insuring smooth recovery, to resort to post-operative drainage also in these least complicated cases.

CASE IV.—*Bronchiectasis of left upper and lower lobe; two-stage operation planned; thoracotomy, firm total adhesion of lung, loosening, tamponade, drainage, closure of thorax; pneumonia on fourth day after operation; exitus on fifth day.*

Male, aged forty years. Bronchiectasis of left upper and lower lobe. Pneumonia two and a half years ago, lasting two weeks; cough never ceased; sputum soon foul. Clinical examination, *x*-rays and bronchoscopy show both left lobes involved.

Operation (April 16, 1917).—Plan: Excision of left lung in two stages (Robinson). Incision in eighth intercostal; four ribs divided posteriorly, parallel to spine; lung found completely and firmly adherent all around; gradually loosened and lifted out with difficulty; pedicle formation of entire lung. Kenyon's drain placed in para-vertebral line in ninth intercostal. Large aseptic gauze tampons packed around lung, separating it from chest wall, pericardium and mediastinum. Wound closed by layer sutures. Patient left operating table in good condition. Head of bed raised. Drainage: First twenty-four hours, 250 c.c. bloody serum; second twenty-four hours, 700 c.c.; third twenty-four hours, 600 c.c.; fourth twenty-four hours, 400 c.c.

In the second half of the fourth day, great difficulty in expectoration; signs of pneumonia appear, to which the patient succumbs on the following day.

Only wound inspection allowed. Lung completely collapsed; pleural cavity contains but a small amount of fluid.

Comment.—In view of the firm adhesions of the lung in its entire circumference to the chest-wall, pericardium and mediastinal landmarks, it might have been wiser in this case to subdivide the operation still further, and attack only the lower lobe at first. Superior lobectomy could then have followed at a later stage of the operation. Proceeding in this way, the pleural cavity might well have been left wide open with drains in place, as a complete post-operative pneumothorax was impossible on account of the firm fixation of the upper lobe. Had this plan of

operation been followed patient might have had a better chance to pull through.

The experience had in this case shaped into a definite resolve, what had before been a mere thought, suggested by a previous unfortunate issue, namely, never again to enter the thorax with a fixed plan, but to be guided by local conditions as found during operation, same as we are in our abdominal work. The method of drainage worked admirably also in this instance.

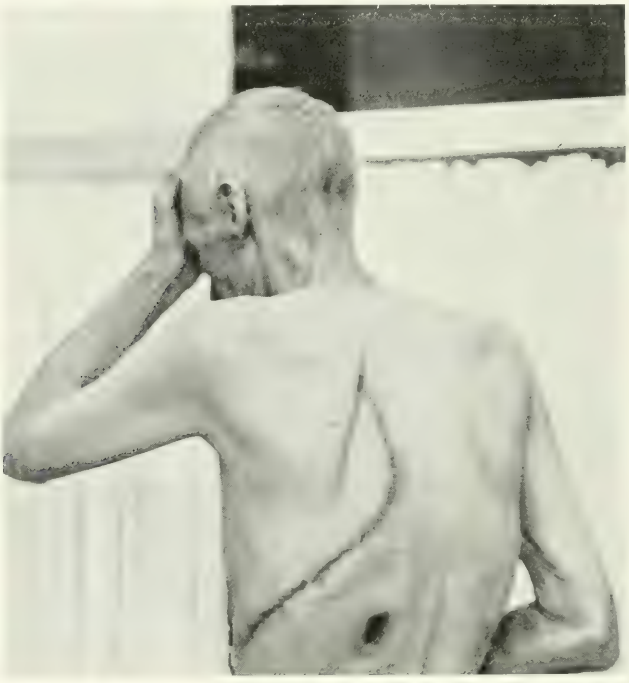

FIG. 12.

CASE V.- *Malignant stricture of esophagus; gastrostomy; exploratory thoracotomy; case inoperable; Kenyon's drainage; recovery.*

Male, aged sixty years; emaciated; cholelithiasis. Stricture of esophagus 34 cm. from incisor teeth; proved by *x*-ray and sound.

Esophagoscopy: Sloughing mass; removed specimen shows squamous-celled epithelioma.

May 10, 1917: Gastrostomy (Witzel). June 14, thoracotomy under intratracheal insufflation, in eighth interspace, curved, periscapular; four ribs divided. Carcinomatous mass in lower end of esophagus; mediastinal glands involved; multiple lung metastasis; therefore, inoperable. Typical insertion of Kenyon's drain, held in place with zinc adhesive plaster. Again it is observed, on raising the head of the bed, that drainage begins at once and continues. Drainage record: First day, 150 c.c.; second day, 65 c.c.; third day, 20 c.c.; fourth day, 25 c.c.; fifth day, 25 c.c.; sixth day, 20 c.c.

Highest temperature 102° on second day; smooth recovery. Tube removed on seventh day after operation. Primary union of chest incision (Fig. 12).

Case VI.—*Cancerous stricture of esophagus; gastrostomy; exploratory thoracotomy; tumor inoperable; Kenyon's drain; recovery.*

Male, aged fifty-two years; constricting tumor 35 cm. behind teeth; specimen removed, shows carcinoma simplex. Preliminary gastrostomy.

June 15, 1917: Thoracotomy in eighth intercostal space; five ribs divided; tumor splendidly adapted for resection as regards location, but forms an inseparable unit with aorta; inoperable; drainage and closure as in foregoing case. After dressings have been applied tube is connected with bottle while patient is still on the operating table in horizontal posture; large amount of air-bubbles pass out of lower end of tube with each respiration, indicating distention of lung. When bubbles cease to appear, tube is clamped. Patient removed to bed and tube there reconnected with bottle, when a few more air-bubbles appear. Again head of bed raised, which is immediately followed by a pronounced bloody secretion flowing through the tube into the bottle, part of the fluid moving to and fro in the drainage arrangement, as can well be observed in the glass tube which interrupts the rubber tubing just before it reaches the bottle. Smooth recovery. Highest temperature 102.4.° Drainage record: on

first six days, 400 c.c., 425 c.c., 25 c.c., 10 c.c., 65 c.c., 20 c.c. per day respectively. Tube removed on sixth day after operation (Fig. 13).

This mode of drainage was applied in two further cases. However, they cannot be used in connection with the question here under discussion, viz., air-tight closure of the pleural sac plus drainage, because in neither of them could the chest be closed air-tight.

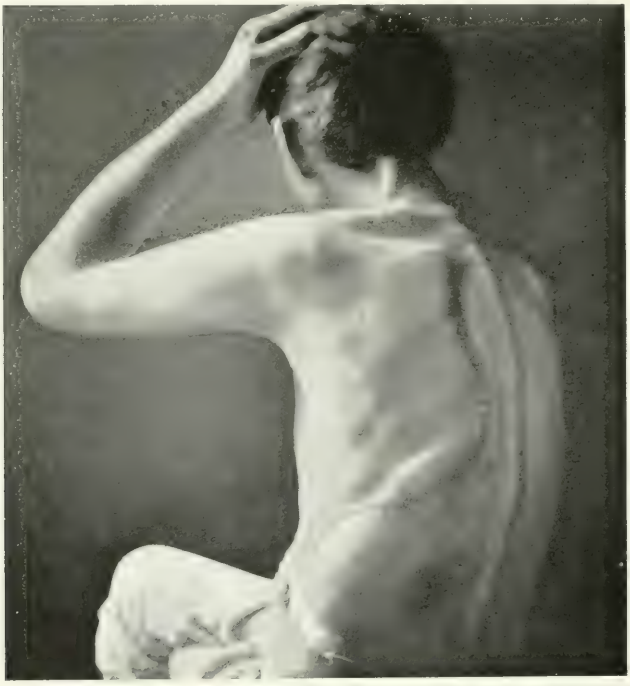

FIG. 13.—Photo taken a few days before patient's death, five months after the exploratory thoracotomy.

The number of patients so far treated with this kind of drainage is small and hardly allows of drawing definite conclusions. Still, the impression which the course of the convalescence of the patients made on the observer was, that this method of thoracic

drainage, originally devised by Kenyon for the after-treatment of empyema in children, is also very useful for post-operative thoracic drainage in general. It fulfils —be it emphasized once more—the demand of air-tight closure of the thoracic cavity (Sauerbruch), thus absolutely eliminating the possibility of a post-operative acute pneumothorax, and, at the same time, drains off wound secretions and pleuritic effusions as they will occur after surgical work within the thorax.

It must be remembered that the tendency of the pleura is, to answer to lesions as they occur in the course of an operation with a rapid, usually serosanguinolent effusion, which, besides being more or less septic in character, will compress the lung of the side operated upon, often push the heart to the opposite side and exert a deleterious effect also upon the physiological action of the other lung. This reaction of the pleura is in great contrast to that of the peritoneum which, after an operation, rapidly forms adhesions rather than a copious exudate. To be enabled to drain off by means of a simple, uncomplicated procedure such pleuritic effusion, beginning with it *immediately* after the completion of the operation, besides assisting the proper expansion of the lung by means of the air-tight closure of the wound, involves, therefore, a tremendous advantage for the patient. It also affords the surgeon the great satisfaction that he can institute drainage, when working in the thorax, the same as in other parts of the body, whenever he finds it indicated.

Kenyon's method of thoracic drainage further fits in nicely with our present clinical procedure when draining other, smaller cavities of the body, *e. g.*, the gall-bladder, urinary bladder, kidney, pelvis, etc. We can watch the character of the fluid from hour to hour and from day to day; we can easily read off the quantity for twelve to fourteen hours and thus determine when drainage may be dispensed with; the bottle used for siphonage can be easily and safely exchanged. For the latter reasons Kenyon's method of drainage is superior in these cases to Tiegel's drain and similarly to Theodore Dunham's pretty device, which he presented before the New York Surgical Society on January 9,

1918, having tried it successfully in 1 case of empyema in a child. Working with either one of these devices the wound secretions drain off into the dressing without giving the surgeon the opportunity of regular observation as to their quality and quantity.

For the same reason Kenyon's drain seems preferable in the after-treatment of operations here under discussion to the method of drainage published by Fred. B. Lund, of Boston, and also its modification by A. S. Taylor, of New York, as well as that of J. Ransohoff, of Cincinnati.

Lund[1] in operating for empyema makes an incision in the skin over the rib below the one he expects to take out, undermines the skin upward, resects the rib above and then sutures the top of the lower lip of the wound in the bed of the resected rib to the lower border of the skin incision (at least, this is the way I understood his remarks made in a discussion). A large hole is thus made for the pus to come out, while a long flap of skin comes down over it, so that the air cannot go in.

Taylor states[2] that Lund puts a rubber tube obliquely underneath the skin; the skin flap falling over the end of the tube, produces automatic closure.

Taylor undermines the skin in the same way, resects a portion of the rib above the skin incision, then elevates a flap of rib periosteum plus costal pleura upward from the wound; this flap is made broad and long enough to permit of its being turned downward over the rib below and sutured to the lower margin of the wound, so as to make a drainage channel which will not readily heal together rapidly with the overlying skin. A suture or two may be placed at each angle of the skin wound, so that the valve action may be controlled. Over the outside a ring of cotton or gauze is arranged to surround the entire wound area, so that no direct pressure is exerted upon the skin flap. An absorbent dressing of good size is then applied to catch the discharge. Every second day a pair of smooth scissors is passed through the channel to prevent the formation of any adhesions.

[1] Annals of Surgery, 1914, lx, 126.
[2] Ibid., 1916, lxiv, 730.

This method gives a perfect ball valve action which can be studied on the table when the operation is finished. Pus and air come out with perfect freedom, but nothing can go back into the empyema cavity; the patients are very comfortable; the lung comes down rapidly into its proper position. Taylor's cases (12 to 15) all healed without fistula and in much less than the average time.[1]

Ransohoff,[2] for the same purpose, advises slipping "an ordinary drainage tube into a collapsible soft rubber tube, which must fit accurately about the harder one for a distance of one inch or more. The soft tube is that ordinarily employed for cigarette drainage. When the harder tube is accurately fitted into the wound, any effort at inspiration will cause the soft outer tube to collapse and prevent the ingress of air. On the other hand, the pressure of the lung from within, with the normal respiratory movement, will be sufficient to open the collapsible tube and permit the escape of whatever pus may be within the chest." In the beginning the collapsible tube is connected with a bottle which is changed as often as necessary. Later on the dressings absorb the discharge. Of course, the inner drainage tube must be made to fit air-tight into the wound in the intercostal space.

Although it has been specifically stated above that the question of drainage in empyema is excluded from this discussion, a suggestion concerning it, with special reference to Kenyon's method of drainage, might here find a place.

In view of the simplicity of inserting Kenyon's drain in an intercostal space, under cocaine, it would seem worth while to test the efficacy of the procedure at present in our military cantonments and general hospitals, with the large and varied number of post-pneumonic pleuritic effusions on hand. By making in addition irrigations with Dakin's solution to dissolve the often present voluminous fibrinous coagulations, the treatment of empyema might eventually be greatly simplified and the lung prevented from collapsing. Drainage could then also be started on any day after the appearance of the effusion, according to

[1] Personal communication and Annals of Surgery, loc. cit.

[2] Jour. Am. Med. Assn., April 15, 1916, lxvi, 1196–7.

the surgeon's judgment. The siphon bottle could easily be exchanged for a freshly sterilized flask filled with Dakin's solution. If this flask were graduated, the surgeon would have quantity, rapidity, force and frequency of the irrigations under his control by simply raising the bottle slowly or quickly, low or high, above the level of the tube entrance, as often as he considers it indicated. By then rolling the patient over on the healthy side, by gently turning him on abdomen and back, by raising the upper as well as the lower end of the bed, the fluid could probably be made to come in contact with all the parts of the pleural sac. It could be made to stay in as long as desired and then be allowed to drain off. Should it be shown that disinfection cannot be properly accomplished by this means—perhaps because the large, infected serous cavity remains closed, insufflation of oxygen (or other gas) through the tube, at regular intervals, might bring better results. (It has been observed in the treatment of incised bronchiectatic cavities that the free admission of air, particularly the insufflation of pure oxygen into the cavities, changes the living conditions of the bacteria that habitate these cavities, some of which seem to be partial anaërobes. It is, of course, understood that this may be different with empyema, which usually is produced by one of the pyogenic type of bacteria. Still, it may be worth the trial.)

Basing our conclusions as to the length of the drainage period on the experience had in the above reported cases in so far as they terminated in recovery, it would seem that three times twenty-four hours are sufficient in the average case of intrathoracic operation. By that time the pleura has practically ceased secreting, at least in larger amounts, and I am almost sure that adhesions of sufficient strength and extent have formed between pulmonary and costal pleura to eliminate the danger of an acute pneumothorax. Nevertheless, it will probably be wise in order to be quite safe, to then exchange the large drain for a smaller one, the latter soon to be left out entirely. In the few cases in which we could so far employ this mode of drainage, we decided, entirely arbitrarily, to leave the tube in place for one week,

having pulled it out of the cavity for one or two inches as soon as the secretion had materially lessened in quantity. This question as to the exact duration of the drainage period will have to be decided on the basis of further practical experience.

The important point is that we have to-day at our disposal a method of post-operative thoracic drainage which is simple, inexpensive, feasible also in the wards, and which, at the same time, answers all requirements from a practical and scientific point of view. It represents a most important factor of safety in the after-treatment of intrathoracic operations.

In view of these facts and in order to further the evolution of thoracic surgery, it would appear advisable—at the present moment at least—to let *every patient* profit by its clinical advantages, that means, to employ the method in *every case* of intrathoracic operation in which the thorax could be closed air-tight.

It is necessary to add that this method of drainage is of importance not only as a post-operative measure, but also in the treatment of cases of so-called internal injury, when an accumulation of air and blood in the chest is threatening the patient's life, *e. g.*, in fracture of the ribs with injury of the lung, etc. The mere air-tight introduction of the drainage tube into the pleural sac may change the picture at once, by allowing the air and blood to escape and restoring normal pressure conditions. Kenyon presented a most interesting case of this type before the New York Surgical Society on October 25, 1916.[1] Many a severely wounded individual in desperate straits may perhaps be tided over or prepared for the required major work by this simple means.

Conclusions.—1. Thoracic operations, just as operations in other parts of the body, often demand drainage.

2. With no adhesions present between the two pleural leaves, an acute post-operative pneumothorax is the inevitable consequence if an ordinary drain—rubber, cigarette, gauze—is introduced. The occurrence of a complete pneumothorax after opera-

[1] Annals of Surgery, 1916, lxiv, 728.

tion greatly enhances the dangers confronting the patient during the after-treatment.

3. It is, therefore, necessary to avoid this complication. This could hitherto be accomplished either by leaving the patient under the influence of differential air-pressure for a greater part of the first twenty-four hours following the operation, after having closed the thoracic wound and then covered the drain ends outside with a large piece of rubber dam (Willy Meyer), or by making use of Tiegel's thoracic metal drain. Both methods have been tried and found satisfactory; both, however, for the question here under discussion, have certain drawbacks.

4. Kenyon's method of draining empyema in children has been found to be useful also for post-operative thoracic drainage in general. It is simple, safe and easy of execution. It permits of satisfactory observation of the quality and quantity of the effused fluid.

5. Kenyon's method of post-operative drainage fulfils Sauerbruch's demand that the thorax be closed air- and water-tight after intrathoracic operations. Yet, it permits of draining off, in an efficient manner, the secretions of the pleura, which follow the majority of intrathoracic operations, and usually are not sterile.

6. The introduction of Kenyon's method of drainage, therefore, bids fair to mean a long step forward in the evolution of thoracic surgery. It greatly adds to the safety of intrathoracic surgical work, and should, for the present at least, be employed *after every operation* upon the thorax in which the free pleural cavity, particularly a "virgin-pleura," had to be traversed.

Summarizing, we may say, that, at the present moment, the successful issue of our surgical work within the thorax seems best assured by combining immediate, complete closure of the incision with an efficient method of simple and safe drainage of fluid and air—without allowing the latter to regurgitate into the chest.

DISCUSSION

Dr. Joseph Ransohoff, Cincinnati:

Does Dr. Meyer still use the air chamber, as was his habit some years ago? Most of us are able to prevent a pneumothorax without its use. Also, does he consider it necessary to have a bottle for drainage? During the last two years in the *Journal of the American Medical Association*, I have described a simple method of putting a soft collapsible rubber tube over the hard-rubber drainage tube, this absolutely closing the chest cavity in cases operated for empyema. The soft-rubber tube has a Mikulicz drain placed over the hard-rubber tube so that all of the drainage can escape easily from the inside. Of course, no air can get in as long as the collapsible tube covers the other and the larger tube fits. There is no objection to draining in a bottle, but in cases of little children who toss about such an apparatus becomes an encumbrance. If a sufficiently large dressing is put on it will take care of any discharge.

Dr. Willy Meyer, New York City (in closing):

Regarding the use of the air chamber and intratracheal insufflation, we have practised everything that has been introduced into medical science. Besides other devices the chamber, I am sure, will forever hold its place. It is an enlarged pleural cavity. If cases in profound shock are brought into the hospital in such a condition that neither general nor local anesthesia can be practised, nothing would prove easier than to put the head of the patient into the positive cabinet, which stands within the negative chamber, turn on the machinery and proceed with the operation under negative pressure.

With regard to thoracic drainage, the bottle is absolutely necessary in my opinion because it shows not only the quality, but the amount of the discharge. Robinson says in his article on lobectomy that a large amount of fluid usually accumulates in the chest when the first stage of the operation is done according to his method. If that fluid can be drained off, it must be better for the patient. One of my patients drained from 700 to 800 c.c.

Dr. Kenyon showed before the New York Surgical Society a most important case. We read, in automobile and railroad accidents, of the serious, often deadly, consequences of internal injuries: such as contusion of the chest, fractured ribs, injury to the lung, and accumulation of fluid plus air the dreaded, pressure pneumothorax. In such a case Dr. Kenyon started this simple tube treatment in a boy of four-

teen, and the condition immediately changed for the better. If the surgeon, seeing threatening symptoms in such a case, would, under local anesthesia, make an intercostal incision, then force his forceps through and put in the tube, with following airtight drainage, many a life might be saved.

Just a suggestion with regard to the treatment of empyema. We have heard what can be done by the Carrel-Dakin method. For many years I have used a wide rib-resection in my empyema work, thoroughly removing the coagula at the start. From now on, however, I shall try this apparatus in adults and if there is not a proper flow, we will wash out the cavity again and again, with the solution, recommended by these authors, hoping, therewith gradually to dissolve the coagulated fibrin. Certainly, if we give the lung a chance, to expand from the start, in connection with proper drainage, it must be a tremendous advantage for the patient.

HEREDITARY OSTEOPSATHYROSIS

By WALLACE I. TERRY, M.D.
SAN FRANCISCO, CALIFORNIA

As the condition of hereditary osteopsathyrosis, or fragilitas ossium, is quite rare it is felt that the publication of a single case is justified.

The history of the patient who has on several occasions been under my care is as follows:

Mrs. S., a widow, aged forty-two years, born in Ohio, entered the gynecological service of the University of California Hospital in October, 1912, for uterine fibroids. She was operated upon by Dr. W. G. Moore, a hysterectomy being done, and was then transferred to my service because of the many fractures she had sustained.

The only thing of importance in her family history was that her father had had blue sclerotics and many fractures. He died at fifty-one. Her mother died from accident at twenty-six. One brother and one sister alive and well. The history of her grandparents could not be ascertained. Her paternal uncles and aunts were normal, so far as fractures were concerned. Patient had measles, mumps and whooping-cough in childhood and probably typhoid fever twelve years ago. One miscarriage, no children.

At the age of eight months the patient had a fracture of one tibia, and from that time to the present she has had at least sixty other fractures, involving most of the long bones, as well as the pelvis and both patellæ. Fractures of the phalanges have occurred from merely shaking hands. Strangely enough, neither femur had been broken until her last admission in 1917, but frequent fractures of her leg bones interfered with her activity as a

professional dancer. Patient seldom called in a surgeon for her fractures, but "set" them herself, and as a result there are numerous deformities. She has noticed that her fractures unite more rapidly than normal, some of them being quite solid in nine days. She was observed by us in May, 1915, when she had a fracture of the right ulna and the right patella. There were marked ecchymoses, but pain and tenderness were much less marked than in a normal individual, and disability was slight. Solid union of the ulna occurred in eighteen days and the callus was very small.

Physical examination showed marked prominence of the frontal bones; marked blueness of the scleræ, due probably to increased translucency, the color being transmitted from the choroid coats; almost complete deafness of left ear. Thorax somewhat deformed from fractures of the right clavicle and several ribs. No evidence of rickets. The lungs were normal; slight murmur at the apex of the heart; abdomen negative except for operation scar; spleen not palpated. Systolic blood-pressure 210, diastolic 155. Hemoglobin, 65 per cent. to 75 per cent.; red blood corpuscles, 4,700,000; white blood corpuscles, 7400; neutrophiles, 59 per cent.; lymphocytes, 35 per cent.; large mononuclears, 6 per cent.; eosinophiles, 0 per cent. The urine usually shows a faint trace of albumin, with some pus cells; no sugar; an occasional hyaline and granular cast. Several examinations showed no increase in earthy phosphates in the urine. The reflexes were normal and her musculature good considering her sedentary life. The Wassermann reaction for lues was negative.

The patient is under normal height but is not grossly deformed, except about the elbows, which show marked irregularity, with limited flexion and extension, the result of repeated fractures, particularly of the lower ends of the humeri. There is no bending of the bones as in osteomalacia.

A number of reontgenograms were taken, some of which are here reproduced. They show a marked thinning of the bone cortex. In Fig. 1 there is to be noted a recent fracture of the right ulna.

When last admitted to the hospital in July, 1917, this patient

had fractures of both legs, the tibiæ and fibulæ, and of the left femur. She stated that while walking to her door her legs gave

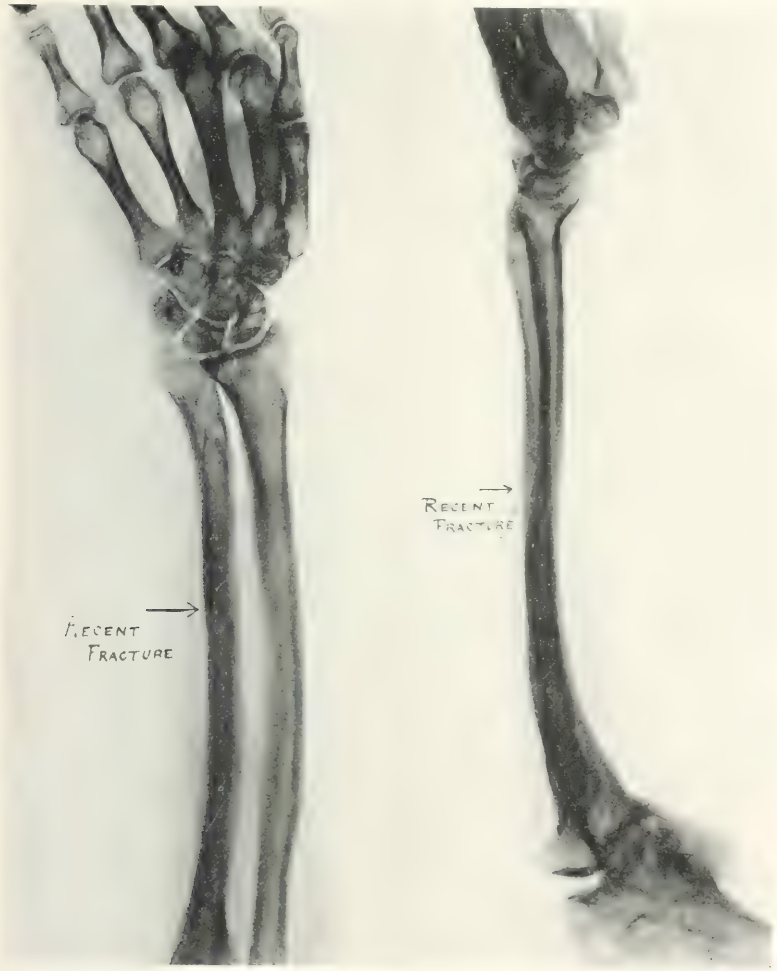

FIG. 1.—Right forearm, showing recent fracture of ulna.

way and she fell to the floor and that the bones broke before the fall. Three months before she had sustained multiple fractures of the left tibia and a fracture of the left patella, but these frac-

tures had united firmly before the last accident. Her last stay at the hospital was for five weeks, when all the fractures were well united.

Lobstein in 1833 published the first case, introduced the word osteopsathyrosis, and referred particularly to the hereditary, so-called idiopathic type of the disease, thus excluding those cases of abnormal bone fragility due to known causes, such as tumors, senility, neuropathies, rickets and inflammatory processes. Up to 1905 only 79 cases could be found in the literature by Doering, and since that time about 40 others have been reported.

The etiology is unknown, but we have reason to think that it is hereditary in most instances, although the published statistics show only 9.8 per cent. of the cases to be hereditary. Lack of inquiry on the part of the physicians and lack of definite information regarding parents on the part of patients could easily make the statistics inaccurate.

The factor of heredity has been emphasized very strongly by Conrad and Davenport in a publication from the Eugenics Record Office on "Hereditary Fragility of Bone." They carefully studied the reported cases and arrived at the conclusion that "a parent who is, or was in early life, osteopsathyrotic will have half of his children similarly affected no matter whom he married; except that if the consort also be osteopsathyrotic it is to be expected that three-fourths of the children will be affected."

More recently Bronson has reported his interesting studies of two families in Scotland: "In the first family, consisting of 55 individuals in four generations, 21 had gray-blue sclerotics," and of the 21, 20 had had fractures. "In the second family, consisting of 8 individuals in three generations, 7 have blue sclerotics, and 4 of these have had fractures and 2 others have a tendency to sprains." In 1900 Eddowes particularly noted the association of blue sclerotics and hereditary osteopsathyrosis, and considered that they were always correlated.

We are better acquainted with the pathology of the disease than with the etiology. The bone cortex is thin and, as Lovett and Nichols have shown, the Haversian systems in the cortical

substance are not formed, so that the cylinders of hard bone surrounding the Haversian canals are lacking, and the strength

FIG. 2.—Right leg, showing thin cortex.

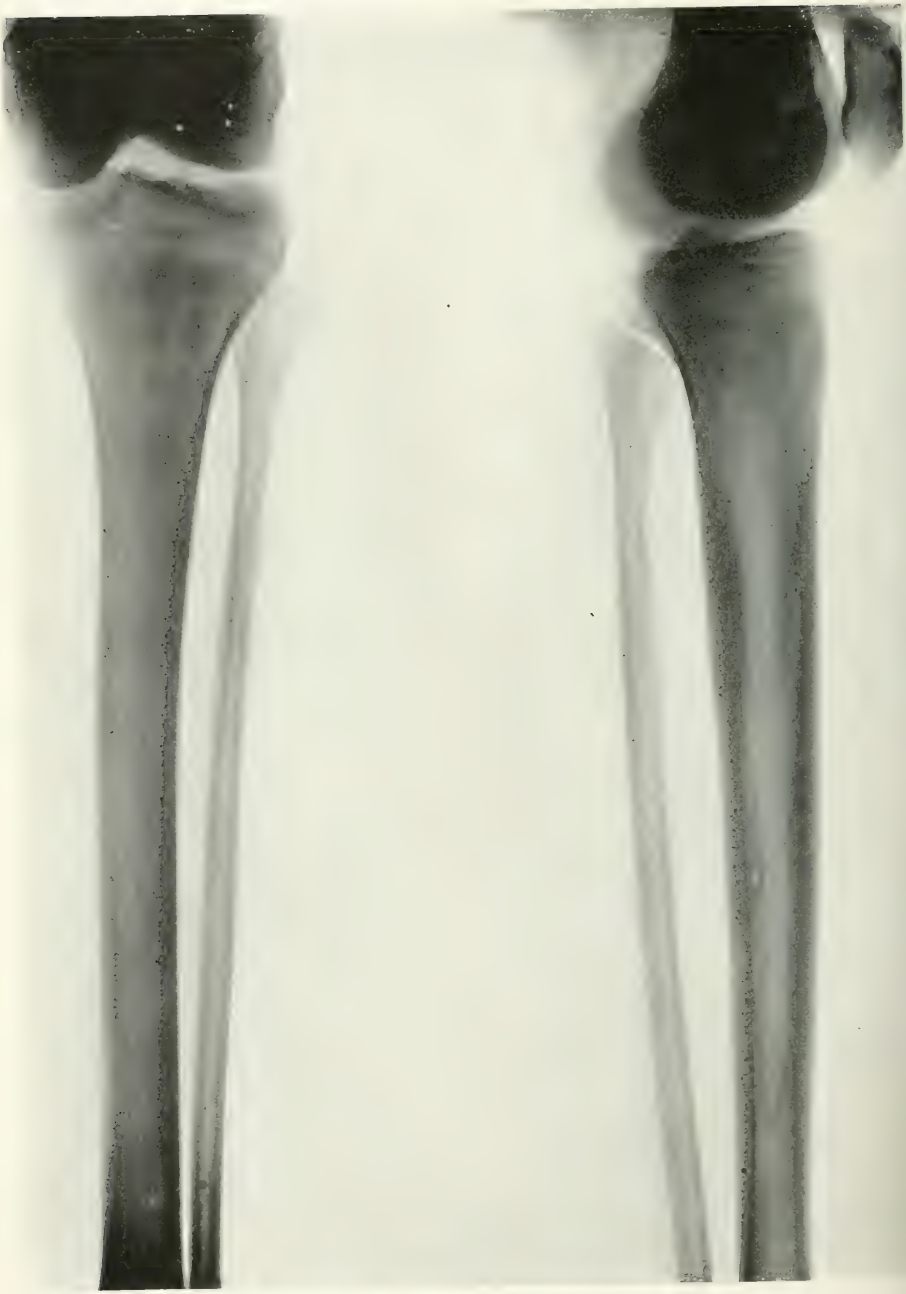

FIG. 3.—Normal bones of leg for comparison.

of the bone is thus impaired. Furthermore, there is a marked tendency in these cases for new bone to be formed by direct metaplasia of cartilage. This metaplasia would probably explain the clinically noted fact of the unusually rapid repair of fractures. I have not found any record of actual tests of the strength of

FIG. 4.—Elbow, showing result of repeated fractures.

osteopsathyrotic bones as compared with normal bones, but shall have such tests made should the opportunity ever present itself.

Nichols and also Looser consider osteopsathyrosis identical with osteogenesis imperfecta, yet clinically Emerson and others note that the fractures in the latter condition are found at birth.

while with osteopsathyrosis the fractures may not occur for a number of years after birth. Furthermore, many of the cases of osteogenesis imperfecta are born dead and few, if any, survive any considerable number of years. It may be that osteopsathyrosis is simply osteogenesis imperfecta in a milder form.

Chemical examination of the bones in osteopsathyrosis does not give us any clue to the etiology: there is a normal proportion of organic and inorganic constituents. Furthermore, studies of the metabolism in these cases have not brought any definite result.

Fig. 5.—Bones of hand.

In a very few cases there seemed to be an increased loss of calcium, in others the calcium metabolism was normal. Bookman reported from his studies on a case of supposed idiopathic osteopsathyrosis that there was a relatively enormous loss in calcium and a retention of sulphur and phosphorus. Unfortunately for these studies the case can scarcely be considered one of osteopsathyrosis, as the radiographs showed multiple cysts in both humeri, the seats of the only two fractures which the patient had sustained. Syphilis quite certainly plays no part in the disease and has been

definitely excluded in many of the recent cases. The Wassermann reaction was negative in the case here reported.

Speculation as to the possible role of the endocrine glands is proper, though as yet unprofitable. A considerable degree of bone fragility results from complete thyroidectomies and changes in the bone occur after removal of the parathyroids. It has also been found that in thymectomized dogs there developed bone cysts and spontaneous fractures. Until, however, our knowledge of the glands of internal secretion is much more extensive we shall not be able to connect them up with hereditary osteopsathyrosis.

Clinical Aspects. It has long been noted that fractures in osteopsathyrotics usually heal very quickly with a minimal amount of callus formation; non-union is rarely seen in these cases, even when several fractures occur simultaneously. While pain is present, it is usually not so severe as in normal individuals, possibly because of lessened trauma. Pain preceding a fracture, as noted in cases of osteomalacia, is not present in osteopsathyrosis. The association of blue sclerotics with osteopsathyrosis occurs so frequently that we must consider them etiologically related.

No drugs have yet been found which influence the condition, and so far as treatment is concerned we are limited to treating the individual fractures conservatively and in accord with the best surgical principles of preservation of function and prevention of deformity.

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Conard and Davenport: Hereditary Fragility of Bone, Eugenics Record Office, Bulletin No. 14.

Bronson: Fragilitas Ossium and its Association with Blue Sclerotics and Otosclerosis, Edinburgh Med. Jour., April, 1917.

The above two references contain nearly complete literature of the subject.

DISCUSSION

Dr. Wallace I. Terry, San Francisco (in closing):

No form of treatment which has proved of any value has as yet been found. I presented this report in the hope that somebody might have seen a similar case and would offer suggestions.

THE TREATMENT OF DISEASES OF THE COSTAL CARTILAGES

By ALEXIS V. MOSCHCOWITZ, M.D.
NEW YORK

It has been my privilege to see quite a number of patients who suffered from diseased costal cartilages, both in my own service and in that of my colleagues. With the exception of an occasional case of proved actinomycotic infection, practically all of the remaining cases were regarded as tuberculous. All the cases were examined with care, in order to determine a possibly infecting organism. Many were reported as positively tuberculous. In others a precise diagnosis of tuberculosis could not be made, owing to an overwhelming secondary infection. Despite the failure to make a pathological diagnosis, we regarded such cases as clinically tuberculous, a view which we deemed fortified because established therapeutic efforts, even to the extent of radical extirpation of the diseased tissues, did not always result in a cure.

On rare occasions I succeeded in permanently curing a patient afflicted with diseased costal cartilages, but the cure was dearly bought, and only at the expense of extensive operations and long invalidism. I also confess that I did not interpret correctly the reason or reasons why I failed to heal many of these cases. If a case was cured I assumed that the supposed tuberculous tissue was completely extirpated. I now know that the real reason was because the last operation, after many unsuccessful preliminary ones, finally removed the last trace of cartilage no matter whether diseased or healthy, thereby permitting a

final closure of the wound. I feel safe in saying that my experience mirrors that of many other surgeons. Indeed, it is therefore not at all surprising to read articles written even as late as the latter part of the nineteenth century, in which the writers regard "tuberculosis" of the costal cartilages as a *noli me tangere* as far as operative treatment is concerned.

The natural history of a patient with diseased costal cartilages is approximately the following: In the very early stage the patient usually presents himself with a fluctuating swelling either directly over the center or near the end of a cartilage. It is stated by some observers, notably Koenig,[1] that the abscess is frequently located at some distance from the diseased cartilage, forming a so-called "Senkungs abscess," but I am not able to verify these observations from personal experience. It may be safely assumed that in a great majority of instances a diagnosis of a chronic or so-called "cold abscess" only is made. In a small number only is the diagnosis made of an abscess, the etiology of which is in the osseous system. Very rarely indeed is the refined differentiation made as to whether bone or cartilage is at the bottom of the trouble. If the location leads to a diagnosis of an abscess due to a diseased costal cartilage it is not generally appreciated that the case is something quite out of the ordinary, and, prognostically at least, a disease of long duration. Even surgeons of great experience frequently fall into the error of transferring their diagnostic as well as therapeutic experiences gained from treating bone abscesses to cartilaginous abscesses. In the course of time the abscess begins to point and is either incised or it perforates spontaneously. The incision of the abscess is very tempting, particularly to those who are not intimately acquainted with the natural history of these cases. It is a ridiculously simple matter to make an incision into the abscess and to pack the cavity, and the uninitiated are usually full of expectation that the abscess will heal like any other well-regulated abscess. This, however, does not happen: a sinus remains which continues to discharge smaller or larger amounts of pus.

The abscess now enters into the second stage, which may be termed the "laboratory stage." Persistence of the sinus gives rise to the suspicion that it may be caused by tuberculosis. Various biological and other tests are now made to confirm this suspicion; in a majority of cases these prove to be positive, even to the finding of the tubercle bacillus.

The abscess next enters into a brief third stage which may be called the "stage of the curette." The old incision is reopened, the fistula and underlying cartilage are curetted and the wound is dressed with iodoform or other irritating substances. Treatment with Bier cups, hyperthermy, and heliotherapy is not infrequently tried. A persistent physician may repeat this maneuver once or twice, but finally the case enters upon the fourth stage, the stage of "unsuccessful surgery."

By the time this stage has been reached there are present usually anywhere from one to a dozen profusely discharging sinuses; curiously enough, these sinuses are located, not as one might expect, over one particular rib, but usually over a number of adjacent ribs. This is such a curious phenomenon that it alone should arouse suspicion that something is radically wrong either with the disease, the diagnosis or the therapeutic efforts, or all three combined. The subsequent course depends really more upon the temperament of the surgeon in charge of the case than upon his scientific acumen.

If the surgeon be of a very enthusiastic temperament the procedure is usually the following: A liberal incision is made over the offending cartilages. Usually a bare area, either on the anterior or posterior surface, is discovered, and the inference is quite properly drawn that the subjacent cartilage is necrotic, or at least so diseased that it will eventually become necrotic. This portion of the cartilage is therefore excised subperichondrally, going well into healthy tissues. All of the granulation tissue, wherever found, is very thoroughly removed by means of a curette. Owing to the fear of a persisting infection of the wound from the preëxisting sinus the wound is lightly packed with either plain or iodoform gauze.

At the first dressing everything looks clean and sweet; in fact, it continues to do so forever if only sufficient aseptic precautions are taken not to reinfect the wound. But to the surprise of the surgeon, not to speak of the patient, the wound does not heal definitely, and again a sinus forms. In the course of time another operation of a similar nature and with a similar result is undertaken. If this is only repeated often enough, *i. e.*, until all of the cartilage shall have been removed, the surgeon will find to his immense satisfaction that the wound has permanently healed.

I confess that I have been guilty of the same course of surgical conduct, and it was only after repeated failures that I began to discover the real cause of my mistakes.

I gained my first lesson when I discovered that contrary to my expectations my operations were truly radical. I found, namely, that tissue extirpated at a second operation, provided of course that the first operation was properly done, was never reported by the pathologist as tuberculous. This taught me that it was not the tuberculous infection which prevented healing.

The second discovery was this: I found that no matter how radically the offending cartilage was removed that at the subsequent operation the ends of the cartilage were found practically unchanged.

The third point of far-reaching importance which came to light was the fact that at reoperations not only the cartilage operated upon but also the adjacent ones were found devoid of perichondrium. I can only explain this peculiar phenomenon by the extreme delicacy and vulnerability of the perichondrium. It is probably this circumstance that has induced Axhausen,[2] Roepke[3] and Martina[4] to give the condition the name "Progrediente Knorpelnecrose," *i. e.*, "Progressive necrosis of the cartilages." I do not consider the name happily chosen in spite of its descriptive nature. It is prone to create the impression that there is something in the nature of the disease which leads to the progressive involvement of more and more cartilages; whereas, strictly speaking, each successive cartilage becomes

involved only through renewed traumata. If these are only avoided there is also an excellent likelihood that no further cartilages will become involved. A perfect example of such a possibility is the following case.

Case I.—A. L., aged seventy-two years, who two years ago made a perfect recovery after a prostatectomy performed by Dr. Edwin Beer, developed a cold abscess over the lower part of the left chest in the spring of 1916. After evacuating the abscess, which contained over four ounces of pus (tubercle bacilli found), cartilage devoid of perichondrium was encountered. Dr. Beer resected the cartilage, going wide of the disease into absolutely healthy tissue. Eventually the incision became a sinus, which was treated with various injections, hyperthermy, Bier cups, etc. The sinus was taken care of excellently, but has remained open ever since that time. I have seen the patient through the courtesy of Dr. Beer, and apparently only the originally affected cartilage is involved.

I am materially strengthened in this observation by the following case reported by Martina (*loc cit.*). An abscess, following typhoid fever (Bacillus coli found in culture), the size of an orange, developed in the region of the third costal cartilage. At the operation, which was done by Payr, a very ample incision was made and the third and fourth costal cartilages were thoroughly examined. The perichondrium was found to be absolutely intact. Payr, however, made the mistake, almost natural one might say, to pack the wound with iodoform gauze. A chronic fistula formed which necessitated a second operation, and this disclosed the third costal cartilage, devoid of its anterior perichondrium, and completely necrotic. There can be no doubt that the chondritis in this case was due to perichondritis, which in turn was caused by the gauze tamponade.

It was at this period that there began to dawn upon me the notion, that it was not the character of the infecting organisms but some factor either peculiar to cartilaginous tissue or to the method of treatment which is the cause of the non-healing of the wound.

Already some years ago I had noted a similar difficulty in performing exarticulations of an extremity in which, owing to the infectious nature of the joint, I deemed it proper to drain. I found, namely, that if the joint was drained with a wick of gauze that it required an interminable time until healing finally occurred. For a long time the exposed joint cartilage looked and behaved like perfectly normal cartilage; subsequently the cartilage appeared as if it would become necrotic; it became discolored and lost its translucency. Finally another interminable time elapsed, until the cartilage really became exfoliated, and then and then only did the exarticulation wound finally heal. Fearing this protracted wound healing I took what at first sight appeared to be an unwarranted risk and closed up such an exarticulation wound by suture. Much to my gratification these cases healed up by first intention and remained healed.

In the course of time I resolved to cautiously apply the principle involved in these joint exarticulations to the next case of diseased costal cartilages which presented itself. No case, however, presented itself until 1912, and was the following:

Case II.—C. M., aged thirty-eight years, was admitted for the first time to Mt. Sinai Hospital, in the service of Dr. A. G. Gerster, to which I was then attached, September 23, 1912. Twelve years ago the patient had a chancre which was very probably syphilitic, although no history of any secondary symptoms is obtainable; he had been treated spasmodically with mercury and KI. One year ago the big toe of the right foot was amputated for a tuberculous osteomyelitis. Ten months ago a tender swelling appeared over the lower part of the chest, to the right of the sternum, which was incised but had never healed. Patient was admitted to the hospital for the cure of this discharging sinus.

On physical examination, in addition to other points of secondary importance (luetic cicatrices and luetic adenopathy), there was found upon the anterior portion of the right chest a circular ulceration, about one-half inch in diameter, the edges of which were sharp and clean cut; its base was covered by unhealthy

granulations. A probe could be passed for several inches in various directions radiating from the ulcer, which accounted for the extraordinarily profuse discharge.

Patient was operated upon September 28, 1912. An incision several inches in length, parallel to the affected cartilage, was made. Necrotic cartilages devoid of perichondrium and a large mass of necrotic fluffy graulations were exposed. The affected soft tissues were excised and curetted away and all the cartilages which were diseased were resected subperichondrally in absolutely healthy tissues. The ends of the exposed cartilages were now covered with flaps of healthy muscle or fascia taken from the neighborhood. The skin was sutured completely so far as possible. In excising the original ulcer so much skin had to be sacrificed that it was impossible to close the entire wound; a small portion of it was therefore packed with gauze. First dressing October 4. Much to our surprise the entire sutured portion of the wound had healed by primary union. By October 27 the entire wound was healed and the patient was discharged cured.

The result was so remarkable as compared to our previous experience that I presented the patient, twenty-five days after the operation, at a meeting of the New York Surgical Society held October 23, 1912. To my chagrin shortly thereafter a sinus formed in the angle of one of the incisions, and after ineffectual attempts at a cure by topical applications, Bier cups, hyperthermy, heliotherapy, etc., the patient had to be readmitted to the hospital November 25, 1912.

The principal reason for his readmission was that a sinus had formed at the site of the previous operation for the tuberculous osteomyelitis of the great toe. This was cured only after laying the sinus wide open and curetting the wound.

In reality I was annoyed more than the patient by the fistula which had formed at the thorax, and I again gained his consent to a further attempt at a cure. He was again operated upon December 19, 1913. A probe introduced into the sinus passed upward and inward. This sinus was laid open and several

branch sinuses were found, leading from the main channel; all of these were thoroughly curetted and were found to lead at various points to newly formed cartilage (chondrophytes) or to cartilage bared and divided at the original operation. Everything was now cut ruthlessly away, all the exposed cartilages were resected in healthy parts and the ends again covered with fascial flaps. By January 8 the thoracic wound was granulating very satisfactorily and the patient was discharged into ambulatory treatment.

He was readmitted July 1, 1913. His principal complaints now were those of a dull pain to the right of the hypogastric region and in the right iliac fossa. The thoracic wound had not completely healed.

In spite of the suspicion of a tuberculous deposit in the abdomen a further attempt was made to cure the thoracic condition. Patient was again operated upon July 5, 1913. The costal cartilages affected were all exposed and removed well into the ribs and into the sternum. After curetting away all the diseased granulations the wound was packed. Very little reaction followed this extensive procedure and the patient was up and about four days later. He was dressed the first time July 16 and the wound was found covered throughout with healthy granulations. July 27 the patient complained of severe headache, he appeared to be drowsy, stuporous and extraordinarily quiet. Physical examination did not reveal anything abnormal, but upon the supposition of a meningeal involvement a lumbar puncture was made which revealed the presence of tubercle bacilli. Pneumonia supervened and the patient died August 2, 1913.

In connection with this case it is important to bear in mind the various pathological diagnoses as reported by Dr. F. S. Mandlebaum:

1. Granulation tissue excised at the first thoracic operation was reported as tuberculous.

2. Granulation tissue excised at all subsequent thoracic operations was reported as non-tuberculous.

3. Granulation tissue excised from the sinus of the great toe reported as tuberculous.

4. Spinal puncture fluid was reported as tuberculous.

As already stated I was so pleased with the primary result obtained in this case that I presented the patient, October 23, 1912, only twenty-five days after the first operation, at a meeting of the New York Surgical Society. Curiously enough my attention was called at about the same time to an article by Axhausen (*loc. cit.*), which had just then appeared.

Axhausen relates in detail the history of a patient afflicted with tuberculosis of the sixth rib in whom the rib did not heal after repeated operations. On the contrary, whereas after the first operation only one sinus existed, which led to the stump of the sixth costal cartilage, after the last operation several sinuses appeared which led to the fifth and seventh ribs as well. It is also interesting to note that just as in my case only the specimens removed at the first operation showed tuberculosis; not the later ones. Axhausen, with characteristic thoroughness, utilized this case to investigate very carefully the reasons of the non-healing of infected wounds of the cartilages. These investigations enabled him to make a number of very important and valuable observations.

Primarily he lays stress upon the great difference in the blood supply of bone and cartilage. Whereas the former is very porous and has a very rich vascular supply, the latter is much more compact and is extremely poor in bloodvessels. This alone would speak for a much more rapid recuperative energy in the former. It is well known, for instance, how rapidly a bone injury becomes repaired, while an injury of cartilage of similar extent remains practically unchanged for a very long period.

In this connection I also wish to mention that as far back as 1899 Lampe[5] studied intensively the vascular supply of the costal cartilages and found that prior to the fourth decennium they have practically no direct or visible blood supply, only that part of the costal cartilages which is directly continuous with the bone appears to be vascularized in the earlier decennia.

The absence of Haversian canals and of cancellous substance in cartilage, both of which are so important in the process of repair of a bone injury, is a second important reason why injuries of cartilage fail to heal. Judging merely from observations upon bone, in which there is a proliferation of the periosteum at the junction of the living and the necrotic bone and which progressively separates the two, it may be argued that a similar occurrence takes place in cartilage. Experiments and examinations of a large number of specimens have, however, shown that although the perichondrium always produces chondrophytes in profusion, these never grow into the cartilage, and thus are of no value in separating the living from the necrotic cartilage. These chondrophytes never become actually continuous with the original cartilage—there is always present a slit-like space between the two which is filled with pus and granulation tissue.

In fact, Axhausen, after a study of the question, found a number of other factors which are lacking in cartilage but are present in bone, all of which tend to a retardation of the reparative process in an injured cartilage. Of all the factors concerned the only one to which Axhausen attaches a slight value is the lytic function of the leukocytes upon dead cartilage, but that is recognizedly of so slight assistance that by the time a piece of necrotic cartilage has been gotten rid of by the leukocytes the adjoining portion of the cartilage becomes affected and also dies. Axhausen leads his readers to believe that eventually every such wound would heal, but it would be practically an interminable time.

Case II of this series is one of special interest because it proves to me that even if it was a failure I was at least on the right track. I argued that either I was not radical enough or that I left infectious material behind. In spite of the negative final result I determined to persevere in the method and to give it another trial. As so frequently happens no other case presented itself to me for a very long time, and even that one was not ideally suitable because the infection was not tuberculosis but actinomycosis. I was of the opinion, however, that that would not make much difference so far as therapy is concerned.

Case III.—J. M., aged thirty-five years, was admitted to Mt. Sinai Hospital May 5, 1916. Seven months ago the patient noticed a swelling in front of the sternum, which was incised at a hospital. A sinus remained for which he was reoperated four months later; at the same time another abscess located beneath the right breast was also incised. Four weeks ago a third swelling appeared, which was also incised a few days ago. Patient lost about fifty-five pounds in weight since the onset of his illness.

On physical examination there were found signs and symptoms indicative of the presence of an effusion in the right pleural cavity. Locally three sinuses were found, all of which discharged large amounts of pus: one was located at the second chondrosternal junction, a second was located in the region of the third chondrocostal junction and the third approximately on a line with the fifth costal cartilage.

Patient was operated upon May 12, 1916. All the sinus tracts were found to intercommunicate. Liberal incisions laid all the sinuses wide open; some were found to lead in front and some behind the costal cartilages; a large area covered with necrotic granulations was encountered and was curetted clean. The costal cartilages overlying the sinus tracts were then all removed. During this procedure the internal mammary artery was injured. After many unsuccessful attempts to surround it by a ligature, owing to the exceedingly dense deposit of cicatricial tissue, the bleeding was finally controlled by a gauze tampon sutured against the bleeding vessel. Because of the long duration of the operation and the poor condition of the patient it was deemed advisable to defer the final steps of the operation to a subsequent session. The wound was therefore packed with a large Mikulicz tampon.

Second operation May 25. The incisions from the former operations were extended laterally. The fourth, fifth and sixth costal cartilages were found to be of a light brownish color and at several points bare of perichondrium. They were resected in healthy parts and the ends of the freshly cut cartilage covered by fascial and muscle flaps taken from the vicinity.

In the region of the fifth intercostal space a separate extrapleural abscess was encountered which was incised and drained by means of a tube. The greatest portion of the wound was closed by suture; entire closure was not possible because of previous cicatrization.

The subsequent course left considerable to be desired. It is true the original foci in the region of the costal cartilages became covered with healthy granulations, but new pus foci appeared in the neighborhood of the wound and required repeated incisions (June 16 and July 4), but finally the patient was discharged into ambulatory treatment August 6, 1916.

He was readmitted September 5, 1916. During the interval the entire wound had broken down and numerous sinuses formed again, which showed retention of pus and called for further revision.

Subsequently the patient's health failed very rapidly. He presented himself from time to time in the "follow-up" department; very slight attempt at healing was discernible. Finally I lost track of him, but I have no doubt that he succumbed to a progressive pulmonary involvement. Incidentally, I may mention that many of these patients apparently die from coëxisting pulmonary disease, particularly in cases of a tuberculous affection of the costal cartilages.

In other words again a complete failure. I believe, however, I had a valid justification in this case. Actinomycosis is at best so difficult to cure that perhaps the blame is to be attached altogether, or at least to a great extent to that, and not to the particular operative method used for its cure.

In the absence of further cases of diseased costal cartilages I began to pay more and more attention to wounds and injuries of other varieties of cartilage no matter where located. I devoted particular attention to infected injuries or to those which were liable to become so, and I have found that when a cartilage of a joint was exposed in a wound, where it was liable to infection, and more particularly when it was traumatized by contact with gauze, it was very liable to become devitalized almost beyond

the possibility of recovery. Furthermore, I have also found that it usually required a very long time before cartilage thus infected became exfoliated. The affected cartilage acts as a foreign body and prevents the final closure of the wound. It is entirely immaterial whether the infecting organism was the tubercle bacillus, or one of the common pus-producing germs. In other words, there exists in these cases a condition quite analogous to diseases of the costal cartilages. It was but natural to deduct from these observations that it was not the tuberculosis of the cartilages which gave us the bad results but any disease of the cartilages.

I was very anxious to prove this observation clinically, but again for a long time no case of diseased costal cartilages presented itself. A case finally presented itself which is particularly convincing, because I was able to follow it from its inception to its final cure.

Case IV.—M. M., aged fifty-five years, was referred to me in November, 1915, by Dr. H. Schwartz, to whom I am also indebted for the following history: In May, 1915, the patient passed through a very severe attack of typhoid fever of six or seven weeks' duration. For several weeks prior to seeing me the patient complained of indefinite pains in the lower part of the left thorax. A few days ago he noticed a small lump in this location, which was rather tender.

On physical examination there was found a swelling, the size of an egg, slightly above the middle of the left costal margin. It fluctuated distinctly and was slightly tender. A probable diagnosis of an abscess, due to a typhoid chondritis, was made, although there was also present the possibility that the abscess was located in the soft tissues only, without any involvement of the cartilage. No consent was obtained for any very extensive operation.

The patient was admitted to Mt. Sinai Hospital and was operated upon November 16, 1915. An incision parallel with the sixth left costal cartilage was made and an abscess containing over an ounce of pus was encountered. A sinus was found which

led underneath the cartilage toward the median line. The cartilage was bare of perichondrium, of a dark brownish color and apparently necrotic. All of the necrotic cartilage was excised and all of the granulation tissue was curetted away. Flaps of fascia and muscle were now brought down and were fixed into the defect between the two ends of the resected cartilages. The skin was sutured in part and the remainder packed with gauze in such a manner that the gauze did not touch the cartilage anywhere but helped very effectively to hold down the aforementioned fascia-muscle flaps. There was primary union of the sutured portion of the wound, but the patient was discharged with a small granulating wound.

Subsequently the patient was under treatment with heliotherapy, hyperthermy, injection of iodin, iodoform glycerin and other irritants, but the fistula failed to close; indeed, another fistula formed. It appeared that each fistula led down to one end of the resected rib. The condition continued for several months, but finally the patient consented to a radical operation.

He was readmitted to Mt. Sinai Hospital and was operated upon April 22, 1916. The old incision was lengthened in both directions, so that it reached approximately from the middle of the sternum to the eighth costochondral junction. The ends of the previously resected cartilage were seen exposed in the wound, appearing just about as they were left on the day of the operation. The entire mass of cartilage uniting the sixth, seventh, eighth, ninth and tenth ribs was excised well into the cancellous tissue of the sternum and the ribs. The entire wound was closed by sutures, except that a small rubber tube drain was inserted into the outer angle of the incision. Primary union resulted and the patient was discharged May 12, twenty days after the operation. The drainage sinus was definitely closed one week later. The patient has remained healed ever since that time.

The case just described was most instructive to me. In conjunction with my failures in the past it taught me the one important lesson in the treatment of diseases of costal cartilage—namely, that "radicality" in the operation means the removal

of every bit of cartilage, because only in operating in this manner can one be certain that no exposed cartilage is left behind, which may again be the starting-point of an intractable sinus. It is true the case required two operations for a final cure, but the first operation was in no sense of the word radical and was never intended to be taken as such. I fully determined to act in my next case according to the principle just outlined and intended to operate in a radical manner at the very first operation.

Case V.—S. D., aged thirty-two years, was admitted upon the medical side of Mt. Sinai Hospital, in the service of Dr. Libman, August 11, 1917. He gave a history of an illness of three months' duration and which, according to the statement of the patient, began shortly after exposure to inclement weather. His principal complaint was that of a sharp, sticking pain in the right lower axilla and in the hypochondrium. He has lost about thirty pounds in weight since the onset of his illness. The temperature chart showed a septic curve. Pus was obtained on aspiration, but in spite of this incontrovertible evidence he declined operation and left the hospital against advice on September 3, 1917.

He was readmitted September 10. During the interval his condition had become materially worse, particularly as far as the constitutional symptoms were concerned. The physical examination showed that the right lung was restricted in its movements; there was a relative dulness on the right side from the angle of the scapula downward, with diminished breath sounds. The blood showed a leukocytosis of 19,000, of which 68 per cent. were polynuclears. Roentgen examination showed no abnormality in the lungs. Fluoroscopy revealed a high position of the diaphragm, with diminished excursion, on the right side. In short we had a typical picture and physical signs of a subphrenic abscess on the right side.

The patient was transferred to the surgical side and operated upon by my adjunct, Dr. Wilensky, on September 11. After a preliminary aspiration an incision was made over the ninth rib, with the center of the incision in the posterior axillary line.

Three inches of the rib were resected. In excising the rib the pleura was accidentally opened, but was immediately closed by suture. The diaphragm was sewed to the pleura throughout the length of the incision.

September 12 the second stage of the operation was carried out and consisted of an incision and evacuation of the subphrenic abscess, which contained over 1 liter of pus, and communicated with the substance of the liver.

The only noteworthy feature during the after-treatment was that the patient complained of considerable pain in the anterior part of the incision, and that while the subphrenic abscess healed completely a shallow sinus remained in the anterior part of the incision. He was discharged, October 21, into ambulatory treatment.

As this sinus failed to close definitely the patient was admitted for the third time, November 12, 1917. From the history and anatomical location I made the definite diagnosis that the sinus led down to the cartilage of the ninth rib. In view of my previous experience I advised Dr. Wilensky to carry out the following radical procedure, which was done November 14: The sinus existing from the previous operation was probed and curetted; a small piece of loose cartilage was also removed. An incision was now carried just over the free border of the ribs from the sinus to the sternum. The entire mass of cartilage connecting the sixth, seventh, eighth, ninth and tenth ribs to the sternum was now completely excised, the ribs being divided externally to the costochondral junction and the cartilage being excised cleanly from the sternum, so that at the termination of the operation not the slightest trace of cartilage was to be seen. A small tube drain was inserted subcutaneously near the old sinus, but the rest of the wound was closed completely.

On November 24 the tube was removed. By December 4 the wound was completely closed and has remained healed ever since.

Epicrisis. There is absolutely no doubt in my mind that the only way to explain this case is that inadvertently there must

have occurred an injury of the extreme outer end of the cartilage of the ninth rib, which became infected from the discharges of the subphrenic abscess. When once the cartilage has become infected in this manner there is no use to waste time by small local operations. I therefore suggested at once the larger but surely radical operation, which led to complete healing in twenty days.

TECHNIC. The technic of the operation is, so to say, self-evident. Nevertheless, my observations have impressed me with the necessity of emphasizing certain important points.

1. The incision runs parallel with the diseased cartilage and should be of sufficient size to enable the operator to assure himself beyond any doubt that every bit of cartilage has really been extirpated. When two adjoining cartilages are involved the incision is made preferably in the interosseous space.

2. It is quite evident that radicality in this operation does not mean, as in so many other operations, the extirpation of everything that is diseased, plus a safe margin beyond it. Rather it means the removal of every trace of cartilage that has at any time either before or during the operation become uncovered of its perichondrium. To be absolutely certain therefore it follows that it is necessary to extirpate the cartilage and to carry this extirpation well into cancellous tissue, both at the sternal and at the costal extremity. This has a most important bearing upon the technic of the operation—namely, not to injure carelessly an adjoining healthy costal cartilage by either sharp instruments or by crude handling. Should such an accident inadvertently happen I would be guided in dealing with the injury by two factors: (1) by the amount of infection present, and (2) by the fact as to whether or not there is any indication for drainage. If no infection is present, or at least none of a severe nature, one might take the chance to close up the wound entirely. Under no circumstances should an injured perichondrium, which exposes the cartilage, be drained or protected by gauze, as such a contingency is sure to be followed by necrosis of the cartilage and sinus formation.

In this connection I wish to mention an occasional and some-

what peculiar experience I had a number of years ago. It followed amputations of the breast for carcinoma whenever the assistant failed to properly support the breast, or even pulled upon it, at that stage of the operation when it was being cut away from the underlying costal cartilages. In a few cases it happened that a bit of perichondrium was torn away from a cartilage. If absolute primary union did not take place, this seemingly trivial accident was followed by an interminable sinus. I went so far as to ascribe this sinus formation to a carcinomatous invasion of the cartilage, but this was never verified on histological examination. Since that time I am always very careful to instruct my assistant not to permit any dragging of the breast. When I look back upon that experience I am convinced that the accident was due solely to the trauma and subsequent infection of the costal cartilage.

3. When cartilage has been exposed for a long time in a wound, and more particularly when cartilage has been operated upon subperichondrally, cartilaginous tissue is deposited by the perichondrium in larger or smaller amounts, and forms so-called chondrophytes. The process is quite analogous to the osteal deposit when the periosteum is irritated. In operating upon bone, as a rule, little attention is paid to this newly deposited bone; occasionally pains are even taken to conserve it. When, however, extirpating a diseased cartilage the total extirpation of the newly formed chondrophytes is most important; failure to do so may mar an otherwise perfect operation, and will surely be followed by a relapse.

4. It is a comparatively simple matter to extirpate the cartilage of the first, second, third, fourth or fifth ribs, and yet do justice to the postulate, to extirpate the cartilage in its entirety, without leaving even the slightest trace behind. This is, however, a matter of some difficulty when dealing with a cartilage belonging to one of the next five ribs—namely, the sixth, seventh, eighth, ninth or tenth ribs. The difficulty is due to the fact that the cartilages of all these ribs are joined to each other by cartilaginous tissue. It is quite evident therefore that in order not to leave

behind any cartilage uncovered by perichondrium it would be impossible to resect only one cartilage of these ribs. It follows therefore that when any one of the cartilages of these ribs is affected and requires extirpation it is absolutely necessary to resect not only the affected cartilage but also the entire mass of cartilage which joins these ribs to each other and to the sternum. This makes the operation one of magnitude, but is, so far as I can see, the only one which is sure to be followed by success.

5. Spontaneous as opposed to artificial disease of the costal cartilages is a malady of advanced life, and is but rarely seen in children or early adult life. I am particular to mention this point, because it is most fortunate for the individual thus afflicted that in later years the upper part of the ensiform cartilage, with which the cartilage of the seventh rib is occasionally connected, is ossified. Were this not the case then it may well be imagined that even complete extirpation of the entire mass of cartilage connecting the sixth, seventh, eighth, ninth, and tenth ribs need not of necessity lead to a cure; a sinus may form at the xiphoid cartilage which eventually would lead to the cartilages of the opposite side. As a matter of fact I found several such cases reported in medical literature.

Röpke (*loc. cit.*) reports two such cases. The first patient was aged thirty-eight years, who was cholecystectomized June 10, 1905. The wound was drained by tube and gauze and healed without any evident disturbances. However, a sinus formed at the upper angle of the incision which led down to a costal cartilage. As the sinus showed no sign of healing the patient was reoperated upon October 3, 1905, and the necrotic cartilage excised in healthy tissue. Subsequently, on account of persistent sinus formation, repeated operations were undertaken, at shorter or longer intervals, necessitating successively the resection of more and more cartilages, until finally practically all of the lower cartilages of both sides had to be extirpated.

Röpke's second case occurred in a man, aged thirty years, and in the more important details is identical with his first case.

A third case similar to Röpke's first case is reported by Müller;[6] even the etiology (operation for cholecystitis) is identical.

In spite of the removal of such an amount of thoracic protection the operation is not followed by the slightest interference with the movements of the thorax or with the absolute comfort of the patient. In the course of time new cartilaginous tissue becomes deposited from the perichondrium left behind, which may even become ossified. A roentgen-ray plate of Case IV of this series shows a large amount of bony deposit where the cartilages were extirpated. On the day that the roentgen-ray plates were taken, about one and a half years after the operation, I found the thorax to be perfectly normal in every respect, and there was a deposit of cartilage or bone that was apparent on the roentgen-ray plate.

6. Just a word regarding the incision which is to be used in these major cases: Originally it was an incision in the course of the sinus, to which one or more supplementary incisions were added in various directions. In the case operated upon in my service by Dr. Wilensky I suggested an incision which extended parallel with the free border of the ribs and extended from the midsternum to well beyond the costochondral junction of the eighth rib. By properly retracting the incision an excellent exposure is obtained of all the costal cartilages which have to be resected. The wound is fairly superficial throughout its entire extent, except at its outer angle. I claim no particular originality for the incision; it was, so to say, self-indicated. I was therefore somewhat surprised when I found in the literature particular incisions described for this operation, which to my mind are needlessly extensive. I refer to the incisions described by Mercade[7] and by Murphy,[8] both of which incisions expose so much of the abdominal wall as to be entirely without reason.

7. In discussing the technic of the operation I wish to particularly discuss in brief the accident which happened to me in Case III—namely, the injury of the internal mammary artery. I have not seen this accident mentioned in any one of the reported cases, and yet it is somewhat surprising that this accident does

not occur more frequently. I have made the interesting observation that, particularly in a case of tuberculosis of long standing, there are to be seen a number of sinuses which enter the thoracic cavity proper in one or more interosseous spaces. These sinuses do not occur anywhere in a haphazard fashion; they have a very definite location—namely, about one-half inch from the margin of the sternum; and judging from this anatomical fact alone, I have gained the impression that the infection has spread inward along the perforating branches of the internal mammary artery. It is in following up these tracts to their ultimate terminations that an injury of the internal mammary artery may occur. As a rule it can be readily controlled by passing a hemostatic ligature around the vessel. Owing to the deposit of massive fibrous tissue in my case it was impossible to do so. The sinuses just mentioned as accompanying the perforating branches of the internal mammary artery have been the cause of a misjudged pathological picture for many years; and many surgeons argued that these fistulous tracts were due to infections which originated within the thorax, such as tuberculous glands, which broke through and made their appearance externally. I believe this is an erroneous observation, and I base my argument upon two reasons: (1) because of the constant anatomical locations of the sinus, and (2) because in the cases in which I was radical enough to follow up these sinuses into the thoracic cavity I have been able to find only a shallow abscess cavity, usually overlying the pericardium, and never even a trace of a gland. A third argument is, that in spite of assertions to the contrary, no one, so far as I know, has ever seen such a sinus formation without any disease of the bone or cartilage.

8. No one as yet has been able to follow a perforation of an abscess due to a tuberculous or other infectious process of a cartilage into the underlying pleura or pericardium. Coincident with the infection there appears to go hand in hand with it a thickening of these structures and of the fascia endothoracica. It follows therefore that injuries to the pleura and pericardium can and should be avoided by exercising care in separating the posterior perichondrium.

9. Finally, I wish to sound a warning that some of these patients do not stand operations well, and I have seen a number in which the operation had to be terminated rather abruptly because the patient went into a condition of shock even when there is no untoward accident, such as perforation of the pleura or pericardium or unlooked-for hemorrhage. I presume this tendency to shock can be best accounted for by the long duration of the illness previous to operation.

Conclusions. 1. Diseases of the costal cartilages may be caused by any one of the pus-producing germs.

2. The infection is caused most frequently by the tubercle bacillus; next in frequency appears to be the typhoid bacillus.

3. Cartilage exposed in an infected wound does not heal and practically always forms a sinus.

4. In operating on infectious cases, in the vicinity of the costal cartilages, it is of great importance to avoid an accidental injury of such.

5. In cases in which the infection is slight a chance may be taken by a complete closure of the wound; under no circumstances should the wound be drained, least of all by a protective gauze packing.

6. If any one of sixth, seventh, eighth, ninth or tenth costal cartilages is involved it is important to extirpate not only the infected cartilage but the entire mass of cartilage which connects these cartilages with each other and with the sternum and the ribs.

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DISCUSSION

Dr. Leonard Freeman, Denver:

I think I can say, with a great deal of certainty, that some of the most unsatisfactory operations I have ever had to do have been associated with this progressive disease of the cartilages in connection with typhoid fever. I have begun with a single operation, following it with one after another until six, seven or eight different operations were done before I was able to remove the disease entirely. Twice I have accidentally opened the pleural cavity. Under the circumstances this is a matter of great moment, not only on account of the pneumothorax but also the infection that may go with it. I wish to congratulate Dr. Moschcowitz upon having formulated a method for the treatment of these cases which does not necessitate multiple operations.

Dr. Stephen H. Watts, Charlottesville, Virginia:

I should like to say that I have had exactly the same experience that Dr. Moschcowitz describes and have worked out the same technic in my cases. I have never been able to get the cases to heal until I have removed all of the cartilage exposed to the wound. I attribute the failure of healing in these cases to the avascularity of the cartilage; therefore, I remove every bit of costal cartilage until the ends of the ribs are exposed.

Dr. John Bapst Blake, Boston:

Dr. Moschcowitz has described most accurately, though without having seen it, a case which I had some years ago; it went from my hands to those of several other surgeons. Unfortunately it was not treated, as he recommends, although unquestionably it was a similar condition; it ended fatally.

Dr. Alexis V. Moschcowitz, New York City:

I regret that owing to the time limit I have not been able to read my paper in its entirety; many of the points mentioned in the discussion are discussed at length therein.

RECURRENT DISLOCATION OF THE LOWER JAW

By JOHN BAPST BLAKE, M.D.
BOSTON, MASSACHUSETTS

Recurrent dislocation of the lower jaw is fortunately not a lesion of frequent occurrence. It may fairly be classed among the more unusual conditions which confront the surgeon. When it does occur, however, it is more than a trivial lesion. It is very painful, is apt to occur at any and all times and requires the service of a trained surgeon for its relief. It is almost never cured spontaneously or by simple retention apparatus, and if left to itself, tends to grow steadily worse until operation of some sort becomes imperative.

Little has been written about this dislocation, and the various operations which have been devised and recommended all have the temporomaxillary articulation for their point of attack. The suggestion offered in this paper is, briefly, to disregard the joint but to lace or bridle the coronoid process to the zygomatic arch, either with wire or with an animal tendon of slow absorbability. This mechanically prevents opening the mouth more than a certain degree, and renders recurrence of the dislocation impossible.

Anatomy. The temporomaxillary articulation is classed (by Morris) as a diarthrosis, subdivision ginglymoid arthrodia. The interarticular fibrocartilage, which is interposed between the condyle of the jaw, the glenoid fossa and ridge of the temporal bone, divides the joint into two separate and complete synovial cavities (except in those occasional cases in which this cartilage is perforated); of these the upper is the larger cavity.

Besides the capsular ligaments, anterior and posterior internal and external and lateral, there are two others of importance, the sphenomandibular and the stylomandibular, both going from the base of the skull to the inner surface of the ramus, below the joint itself.

"The chief movement of this joint is of (*a*) a ginglymoid or hinge character, accompanied by a slight gliding action, as in opening or shutting the mouth. In the opening movement the condyle turns like a hinge on the fibrocartilage, while at the same time the fibrocartilage, together with the condyle, glides forward so as to rise upon the eminentia articularis, the fibrocartilage reaching as far as the anterior edge of the eminence, which is coated with articular cartilage to receive it, but the condyle never reaches quite so far as the summit of the eminence. Should the condyle, however, by excessive movement (as in convulsive yawn) glide over the summit, it slips into the zygomatic fossa, the mandible is dislocated and the posterior portion of the capsule is torn. In the shutting movement the condyle revolves back again and the fibrocartilage glides back, carrying the condyle with it. This combination of the hinge and gliding motions gives a tearing as well as a cutting action to the incisor teeth without any extramuscular exertion.

There is (*b*) a horizontal gliding action in an anteroposterior direction, by which the lower teeth are thrust forward and drawn back again. This takes place almost entirely in the upper compartment, because of the closer connection of the fibrocartilage to the condyle than to the squamosal bone and also because of the insertion of the external pterygoid into both bone and cartilage. In these two sets of movements the joints of both sides are simultaneously and similarly engaged. The third form of movement is called (*c*) oblique rotatory, and is that by which the grinding and chewing actions are performed. It consists in a rotation of the condyle about the vertical axis of its neck in the lower compartment, while the cartilage glides obliquely forward and inward on one side and backward and inward on the other, upon the articular surface of the squamosal bones, each side acting

alternately. If the symphysis be simply moved from the center to one side and back again, and not from side to side, as in grinding, the condyle of that side moves around the vertical axis of its neck and the opposite condyle and cartilage glide forward and inward upon the glenoid fossa. But in the ordinary grinding movement one condyle advances and the other recedes, and then the first recedes while the other advances, slight rotation taking place in each joint meanwhile." (Morris.)

Scudder, Speed, Stimson and others agree in saying that recurrent dislocation of the jaw usually demands operation. One or two of the older writers mention the injection of iodin in the neighborhood of the joint, obviously with the intention of setting up a reactive process which would favor the formation of adhesions and so limit the excursion of the jaw by tying up the joint. Most authors, however, suggest an open operation, directed against the joint itself, and usually consisting in the removal of the interarticular fibrocartilage or suture of this cartilage to the periosteum of the condyle; suture or reefing of the capsule is also recommended.

This operation has been done, and apparently successfully, though from a theoretical stand-point at least, the removal of the interarticular fibrocartilage might well result in increasing instead of diminishing the tendency toward dislocation, since it would remove one piece of tissue from the joint cavity and thus remove one element which normally tends to prevent dislocation. There are, moreover, two other definite disadvantages in this procedure.

In the first place the temporomaxillary articulation lies very deep. It is hard to reach for the purpose of careful detailed attack, as it lies deep below the surface of the head and is surrounded by good-sized arteries and nerves; a clear dry field is hard to obtain and accurate work on the joint is consequently far from easy. In the second place, efforts to limit the motion of the joint, applied to the joint itself, act manifestly at poor mechanical advantage compared to forces tending toward hyperextension; the latter act on the chin or body of the jaw and by leverage, which becomes more and more powerful according as

the dislocation force is applied farther and farther from the joint. In the classical operation we are trying to oppose this powerful leverage by a plastic on the joint itself. It is obvious therefore that even if the operation does tend to diminish the chance of dislocation (which seems questionable) it is working at a decided disadvantage mechanically to trauma and muscular action.

The probable reason that the operation has been successful in the past is that whatever else it has accomplished it has caused a large mass of scar tissue to form in relation to the joint, has partially destroyed the joint and by virtue of the retentive bandage applied after the operation, and sometimes worn for weeks, has given the scar time to grow firm without being subjected to stretching; this materially tends to limit the range of motion in the joint, hence makes subsequent dislocation less likely.

In view of this it is strange that tying up the coronoid process, or the tissues inserted upon it, to the zygoma has not been suggested before. Perhaps it has been recommended, but I am unable to find any reference to it. This procedure is less difficult than any careful and accurate work on the joint itself, and, further, it acts to a much greater mechanical advantage in that the coronoid is 3 or 4 cm. in front of the joint and is by so much in a better position to withstand trauma tending to dislocation. With this in mind the following operation was devised and performed: The patient, a man, aged twenty-seven years, was rather a pugnacious individual; he had frequent and violent physical contact with his fellow-men; during these gentle passages at arms he suffered dislocation of the jaw not once but many times, and on rapidly recurring occasions. As a result of this he gradually became unable to laugh without dislocation nor could he yawn without the same inconvenient occurrence. When I saw him he could not even sleep (especially if, as often happened, he took a few social glasses as nightcaps) without imminent danger of waking to find his mouth wide open and his chin fixed upon his chest, and being compelled to seek immediate

surgical aid. It was asserted that his dislocated jaw was reduced at the Boston City Hospital Relief Station, near which he lodged, at least forty to fifty times, sometimes more than once in a single night. In spite of the frequency of the lesion, which was bilateral, he never was able to reduce it himself. He had tried bandages, but possibly did not wear them long enough for a fair trial; operation was obviously the only form of treatment that offered hope of success. After careful examination I was impressed with the disadvantages of attacking the joint itself in a condition so marked as this; and remembering the familiar method by which the lower jaw bone is held to the skull in the mounted skeleton (a spring tacked above to the temporal bone and below to the coronoid process), I was impressed with the idea that something of this nature might be effective—that is, that the coronoid process be bridled to the bony skull, and the zygomatic arch suggested itself, at a glance, as the obvious anchorage.

The patient agreed to the operation, understanding that he must assume some chance, since there seemed to be no precedent for the procedure. An incision was made along the lower border of the zygomatic arch and the fibers of the masseter separated from it. This incision was well above Stenson's duct and is parallel to the facial nerve fibers. With some difficulty the coronoid process was reached. It was much deeper than had been anticipated, and I was not able to do what I had originally planned; this was to drill through the tip of the coronoid, thread a piece of silver wire through the hole and lace this over the zygoma. I therefore looped the wire first over the zygoma and then brought it down and carried it through the insertion of the temporal muscle and the periosteum on the front of the coronoid, twisted the ends together, flattened it and closed the wound without drainage. The wire loop was long enough to allow the jaw to open for 2 cm., or one inch between the incisors. The masseter was carefully sutured to its origin; bandages held the jaw closed and the wound healed by first intention. The jaw was immobilized three weeks, probably longer than necessary; for some time the patient either could not or would not open the teeth more than 1 cm., saying either that it hurt or that he was still afraid

it would slip. Gradually confidence and a wider range of motion returned. Now more than a year after the operation his jaw is normal and reliable in every way, the excursion being about 4 cm. at the incisors. The roentgen rays show that the wire has twisted from its original position, but it does not cause any discomfort and gives a mental sense of security to its somewhat excitable and erratic possessor.

In the discussion of this paper, Major Homer Gage reported that this patient applied for enlistment, but was rejected because of a theoretical possibility that the dislocation might recur. The writer believes this to be absolutely impossible.

I should certainly try this method again on similar cases. I am inclined to think that on the next occasion I should use kangaroo tendon or chromic gut instead of wire, though I am not quite certain on that point. I should not waste time trying to drill the bone but should go directly through the structures on the front of the coronoid process and should not immobilize the parts for more than for two weeks. Careful suture of the masseter is essential both from the point of strength and of cosmetics.

Blair has suggested banding two opposing teeth and then tying the bands together with silk gut: in early cases which had recurred but a few times this might perhaps be sufficient. Injections of iodin are not indicated.

Conclusion. Recurrent dislocation of the jaw should be treated by operation. The coronoid process or the insertion of the temporal muscle into it, should be tied up to the anterior part of the zygomatic arch. This may be done with silver wire or with slowly absorbable suture material. The operation, though not so easy of execution as it seems on paper, is less difficult than the attack on the temporomaxillary joint, is much more logical and more mechanically efficient: it does not injure important structures and the scar is not disfiguring. The result should be 100 per cent. success.

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DISCUSSION

Dr. Homer Gage, Worcester:

The patient referred to came under my observation in the base hospital at Camp Devens. He complained of constant pain, so much increased by chewing his food that he was unable to eat, and was extremely tender to touch. Removal of the wire was considered, but as it seemed as if the dislocation might return it was finally decided to grant him a discharge, much to his satisfaction.

Dr. Joseph Ransohoff, Cincinnati:

Regarding the subject of wiring bones for fractures, a study of this work was done by Dr. Halsted, of Baltimore. He was asked if he ever had to take the wires out, and he said he had never had such trouble; most of us are not so fortunate.

Dr. John Bapst Blake, Boston (in closing):

This patient's story to me was that he was not permitted to enter the army because he could not open his mouth more than an inch. I suspect that his statements vary to suit circumstances. I doubt very much if this wire actually hurts him. In another case I should use kangaroo tendon instead of wire.

CLINICAL OBSERVATIONS CONCERNING MALIGNANT TUMORS OF THE JAWS

By A. J. OCHSNER, M.D., LL.D., F.A.C.S.
CHICAGO, ILLINOIS

It has seemed worth while to review the histories of my cases of malignant tumors of the upper and lower jaws from the standpoint of the clinician.

For the sake of convenience I have chosen 100 consecutive histories of cases operated on by me at the Augustana Hospital since 1901, and have had these carefully analyzed by my assistant Dr. Yngve Joranson, with the results shown in the accompanying tabulation. During the same time a large additional number of cases have come under my observation which were so advanced that an operation could not possibly benefit them. None of these cases were included in this series because they were not admitted to the hospital. There is, however, one observation which should be recorded concerning this group of cases—namely, that all of them had been previously operated upon and that none of them had been operated during the early part of their illness by the use of the actual cautery.

All of these histories were chosen from this one hospital because of the advantages of uniformity in the recorded account of all cases. The number 100 was chosen because it seemed sufficiently large and because of its convenience.

The microscopic sections of every case have been preserved in the hospital laboratory, and all have been studied by myself personally in connection with my assistants.

Every case presenting itself that seemed to have the slightest chance of permanent recovery was operated upon without regard to the immediate danger from the operation, because an operative death seemed preferable to the alternative without an operation.

The actual cautery was used in every case in a most vigorous manner. In a number of cases this was repeated at several sittings. Two cases died from hemorrhage from the carotid artery where the tumor had extended into the neck and where the cauterization had reached deeper than it had seemed at the time of the operation and the wall of the artery had become gangrenous and ruptured a week after the operation. In these cases ligation of the common carotid artery should have been made at the conclusion of the operation.

The oldest one of my cases operated by means of the cautery has lived twenty-nine years since the operation and is still in excellent health. This was a case of extensive sarcoma of the lower jaw resulting from an epulis. In this case I removed all of the molars and bicuspid teeth of the left side and destroyed the soft tissues to a distance of 4 cm. in diameter and heated the bone so that about one-half of this portion of the jaw was exfoliated later, leaving enough, however, to serve as a support for the remaining portions.

I wish to direct attention especially to the value of ordinary soldering irons heated in a gas flame to a red heat for cauterizing these tumors. The tremendous heat given off by these irons seems to penetrate the deep tissues and destroy the malignant growth at a distance.

Laboratory experiments have proved that carcinoma grafts in mice will not grow after being exposed to a temperature of 160° F., and it has seemed to me likely that the heat from these soldering irons may destroy the carcinomatous tissue for a considerable distance from the point of actual cauterization by heating the tissues to a higher degree than 160° F. For this reason we leave the cautery iron in contact at each point for a considerable period of time.

Another important practical point to which we attribute a low mortality in serious cases lies in the position of the patient on the operating table and later on in bed.

During the past ten years all patients of this group have been anesthetized in the following manner: Half an hour before beginning the administration of ether, $\frac{1}{4}$ grain of morphin and $\frac{1}{100}$ grain of atropin were given hypodermically. The latter remedy prevents the accumulation of mucus in the pharynx and the former reduces the sensitiveness to heat. The patient is then very thoroughly anesthetized with ether in the horizontal position. Then the patient is placed in the inverted Trendelenburg position, with the head elevated, so that the body is placed at an angle of 45 degrees. This causes an anemia of the brain which will prolong the anesthesia sufficiently so that the operation can usually be completed without giving any additional anesthetic. A moist gauze sponge is placed in the mouth so that blood cannot trickle down into the pharynx during the operation. If the patient shows any difficulty in breathing through the nose, large catheters are introduced through the nose into the pharynx and the patient permitted to breathe through these catheters.

In this way the patient is enabled to exhale most of the ether by the time the operation has been completed. He is then placed in a semisitting position in bed. Since introducing this plan we have not had a single case of postoperative pneumonia in these patients, while before that time all deaths which did not result from shock, aside from the 2 cases of hemorrhage, were due to pneumonia.

The following data were collected from an examination of the histories of 100 cases of malignant tumor of the jaws treated by me at the Augustana Hospital since 1901. In considering the kind of growth present in each case the following relation was found to hold:

67 per cent. carcinoma.
16 per cent. epulis.
16 per cent. sarcoma.
1 per cent. chondrosarcoma.

The origin of these new growths was noted and in the cases of carcinoma and epulis the following distribution was found:

47 cases originated from the inferior maxilla.
25 cases originated from the superior maxilla.
6 cases originated from the antrum of Highmore.
3 cases originated from the cheek.
1 case originated from the parotid gland.
1 case originated from the ossis palati.

In the sarcomatous growths the examination showed that:

8 cases originated in the superior maxilla.
4 cases originated in the inferior maxilla.
3 cases originated in the parotid gland.
1 case originated in the soft palate.
1 case originated in the cheek.

It will be observed that in the cases of carcinoma the majority affect the lower jaw. The cases further showed that the most usual location was in the vicinity of the molar teeth. It seems probable that here on the lower jaw, where food and débris are allowed to accumulate, at the site of the molar teeth, where tooth decay usually first takes place, an atrium of infection can be most easily established for the production of malignancy.

In reviewing the predisposing factors in connection with the origin of these new growths, as stated in the histories, it seems that the teeth play the leading role, and in the physical examinations it further appears that the teeth, in every case without exception, were either carious or loose, or else, by the addition of bridge-work and crowns, afforded a breeding-place for bacteria.

Irritation seemed to be the second most common exciting cause. Tobacco, either in the form of chewing or smoking, protruding bicuspid and molar teeth, bruising the mucous membrane, and various other things, such as the holding of nails in the mouth, seemed to serve as irritating factors.

The frequency of occurrence of these malignant tumors in the male was found to be much lower than the percentage given by Blair; 72 of the cases occurred in the male while 28 affected the female. The percentage for the female was considerably lower

in the cases of carcinoma than in those of sarcoma and epulis. Of the 67 cases of carcinoma it was found that only 11 were female patients, while in the 33 cases of sarcoma and epulis 17 were female patients.

As to the duration of the condition before the admission of the patient into the hospital the following facts were determined:

25 per cent. of cases entered before the third month.
25 per cent. of cases entered before the sixth month.
23 per cent. of cases entered before the second year.
27 per cent. of cases entered after the second year.

In 65 per cent. of the cases no statement was made with regard to lymph gland involvement. Of the remaining 35 cases, 25 showed enlarged glands.

The mortality following these operations was as follows:

3 per cent. died during the first day following operation.
4 per cent. died before the fifth day.
5 per cent. died before the twentieth day.
3 per cent. died before the fortieth day.
5 per cent. died after the fortieth day.

The total mortality of the patients while in the hospital amounted to 20 per cent. All of these fatal cases, except two, were carcinomatous, the two exceptions being sarcomatous.

It is interesting to note that in 40 per cent. of these fatal cases a previous incomplete operation or an excision of a piece of tissue for diagnosis had been performed. In the balance of the cases injection of iodin or oil, application of plasters or acid, teeth extraction following the appearance of the lesion, or the roentgen ray application had been carried out.

Of the 100 cases treated in this series 15 returned with recurrences; 10 returned once, 1 returned twice and 4 returned three times. The permanent results of this series of cases has not been determined.

Conclusions. Our observations seem to warrant the following conclusions, many of which have been discussed in the works of Scudder, Perthes, Blair and others:

1. Malignant growths seem slower in making metastases in the

jaws than in many other parts of the body. This is specially true of distant and general metastases.

2. Metastases occur more frequently and earlier in the course of the disease when the carcinoma is located in the lower than when located in the upper jaw.

3. The mortality in primary early operation is almost nothing; the results are exceedingly favorable. In late operations and in secondary operations precisely the opposite is true.

4. It is of the greatest importance to destroy the growth and adjoining tissues for a distance of 2 cm. from the edge of the growth, with the cautery at the original operation, because a partial operation is usually followed by inoperable metastases.

5. Malignant tumors of the jaw are much less likely to recur when removed with the actual cautery than when removed with the knife, although the latter operation may have been carried out with the same degree of thoroughness.

6. In case of deep cauterization extending to the neck, if one suspects injury to the walls of the bloodvessels these should be ligated at the conclusion of the cautery operation.

7. It is a good rule to make the primary removal much more extensive than seems necessary, because even then the amount removed will be much less than what one will be forced to remove in case of recurrence.

8. The histological appearance of epulis indicates greater malignancy with each successive recurrence after repeated removal. If removed thoroughly with the actual cautery during the first operation this tumor does not recur.

9. Cases that have had teeth extracted and partial operations performed by dentists before coming under our observation have almost invariably died from inoperable metastases within two years following the original interference, especially in carcinoma of the lower jaw.

10. In sarcoma it seems best to excise the entire jaw on the side of its occurrence. In carcinoma, on the contrary, deep destruction with the actual cautery seems to bring better results.

11. Malignant ulcers having their origin in the embryonic

tooth-matrix or in the surrounding mucous membrane which have invaded the bone can still be treated successfully with permanent recovery if widely removed with the cautery, care being taken to keep the cautery iron in contact with the bone sufficiently long to destroy the deep tissues.

12. Malignant polypi of the antrum may become infected, producing empyema, thus causing the surgeon to overlook the malignancy, and resulting in a fatal delay.

13. Carcinomatous ulcers of the gums are frequently mistaken for benign, tuberculous or gumatous ulcers, and occasionally for actinomycosis, and *vice versa*.

14. The inverted Trendelenburg position is an exceedingly valuable aid in these cases.

DISCUSSION

Dr. James E. Thompson, Galveston:

I think we are all indebted to Dr. Ochsner for the splendid way in which he has presented this subject. There are, however, one or two points which are of importance and which refer to the necessity of correlating our knowledge of pathology and treatment. We cannot advance in our ultimate knowledge of end-results in jaw tumors until we lay down first and foremost the basis of their pathology. In other words, it is absurd for us to collect a large number of tumors and present a list of primary and final mortality unless we know what we are dealing with. We all know that if we are dealing with a pure, round-celled sarcoma arising from the antrum of Highmore, nothing in the world can save that patient. No man can remember one that has recovered. This is one end of the argument. On the other hand, tumors that are pure myelomata (called by some pathologists giant-celled sarcomata) can be cured completely, with a partial operation, such as local shelling out.

I desire to lay emphasis on the fact that we must have a foundation of sound pathology before we accept statistics as of any value whatsoever. Carcinoma of the upper jaw usually arises from the mucous membrane lining the antrum. The condition is very serious, because the tumors often reach considerable size before they are detected. Carcinomata arising from the lower jaw arise from the mucous membrane of the gum. These tumors are usually recognized much earlier and are, therefore, more amenable to treatment.

A word or two regarding metastases. In the upper jaw metastases are very rarely met with in the life history of a sarcoma. In carcinoma arising from the antrum of Highmore they are also very seldom seen. In the lower jaw, sarcoma arising from the periosteum is rarely attended by glandular metastases, but if anything a little more frequently than in the case of the upper jaw. Epithelioma of the gum in both upper and lower jaw is associated with metastases of the glands in the majority of cases. During the last few years, I have seen several cases of metastases of the glands of the neck following periosteal sarcoma of the lower jaw. At the present time it is very difficult to formulate a hard and fast line of procedure as to whether we should or should not remove the lymphatic glands in all cases. I am afraid, as the result of my experience, that I shall never dare to leave the lymphatic glands of the neck behind in any subsequent case of sarcoma of the lower jaw.

Dr. Ochsner has pointed out the only proper line of treatment in these tumors; namely, thorough removal at the earliest possible date.

Dr. Albert J. Ochsner, Chicago (in closing):

Regarding the pathology of these cases I would say that we have the microscopic sections of each one and I have personally studied every one of them. We have no microscopic section of any tumor which I do not personally examine, and we have no tumors without sections. I taught pathology for eleven years before I took up surgery.

Regarding the tumors of the antrum, I would say that of late we have immediately removed the eye and destroyed all of the tissue for a long distance around the tumor with the cautery. In the early cases in which we left the eye in fairly advanced cases we lost all patients, but since removing the eye at the time of the primary operation we have been able to save a number of these patients. In case of invasion of the lymphatics we remove the glands with the electrocautery, making the entire dissection of the neck with the cautery. A few days ago I saw a case in which fourteen years ago I removed the lymphatics in this manner, the patient having been operated twice before elsewhere, each time suffering from recurrence.

THE SURGICAL TREATMENT OF THE CIRRHOSES OF THE LIVER AND THEIR COMPLICATIONS

By W. J. MAYO, M.D.
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Reaction of the liver to chronic irritation of any kind is in the nature of a connective-tissue disease. The condition was first described by Laënnec, and called cirrhosis by him because of the tawny, yellowish color of the atrophic form. The meaning this term carries to our minds is that of a sclerosis, which perhaps more nearly represents the actual condition. This connective-tissue deposit may be local or general and its morphology varies like the patterns of a carpet. A tendency has been exhibited to make minute and complicated classifications based on pattern designs. But if we bear in mind that the liver cells are all alike, sharing equally in function, and that the natural reaction of the liver to chronic irritants, without regard to kind, is the development of connective tissue, as about cancer, tuberculosis, syphilis, etc., the basic fact will be established without being lost in a mass of morphologic detail. On the contrary, the response of the liver to acute destructive irritants, whether bacterial, toxic or chemical, is in the nature of an acute fatty degeneration.

In studying the causes of cirrhosis, perverted functions of the liver will be found. Briefly, it may be stated that the functions of the liver are largely the metabolic completion of processes started in the gastro-intestinal digestion of foods: (1) Carbohydrates with the development of saccharids, the body coal, which are used for heating and energizing the body. The ash is eliminated as carbon dioxide by lung ventilation. (2) Amino-

acids, of which 18 have been identified resulting from protein digestion, used in tissue building as well as in the development of heat and energy. Urea is one of the end-products. (3) Metabolism of fats. The liver acts as a clearing house for these three kinds of food products, converting one into the other, maintaining an equilibrium, and supplying the demands of the tissues by way of the blood stream. The thyroid secretion, as shown by Plummer and Kendall, is the hormone which is most concerned in liberating the contained energy. (4) The liver excretes bile, a valuable adjunct to the intestinal secretions, which contains pigments derived from the blood and various lipoids, of which cholesterin is the best known. (5) The defense function in which protozoa, bacteria, toxins, and chemical poisons are destroyed and eliminated. The gastro-intestinal tract is most important in the first three functions; the spleen participates in the last two. Therefore, the pathology of the liver cannot be studied without cognizance being taken of the splenic filter, which is so closely related to the liver in its physiology and pathology.

Types of Cirrhosis. It is evident that the chronic irritants resulting in the deposit of connective tissue in the liver, and which we recognize as cirrhosis, must arrive through the portal or systemic circulation or through the biliary channels. The cirrhoses then naturally divide themselves into two groups: (1) Portal cirrhosis, in which the irritants, bacterial, toxic and biochemical substances, are received from the intestinal tract and from the spleen by the way of the portal vein, and in which the connective tissue is deposited about the radicles of the portal vein. (2) Biliary cirrhosis, in which the infectious agents reach the biliary ducts by extension of infections from the gall-bladder and great bile-ducts, or from hematogenous infections commonly portal or, not rarely, systemic, such as those following pneumonia, typhoid, focal lesions, etc., and in which the connective-tissue deposit is related to the biliary ducts. The many varieties of cirrhosis described are to be looked on as variations and combinations of these two main divisions.

Portal cirrhosis when advanced gives rise to clinical symptoms

which depend on portal circulatory obstructions shown by ascites and gastric hemorrhages. Jaundice is absent or a terminal condition. Local areas of portal cirrhosis are not infrequent and are often without symptoms.

Biliary cirrhosis, on the contrary, depends on infections in the biliary ducts, and if the whole or the greater part of the liver is involved jaundice is an early, prominent and continuous feature. Ascites is absent or a terminal manifestation. It would appear that we ordinarily recognize as biliary cirrhosis only the late stages of a relatively frequent liver condition after more or less permanent and extensive damage to the liver tissue has taken place. Infections of the gall-bladder and biliary tract are often accompanied by localized cirrhotic processes without definite symptoms.

The spleen will be found to be enlarged in a high percentage of both portal and biliary cirrhoses, and it seems altogether probable that in a certain number of cases this enlargement is primary and causative. However, in many cases the enlarged spleen may be a secondary manifestation of disturbed portal circulation, and the consequent inability of the spleen to rid itself of the toxic products strained from the blood is the cause of the splenomegalia. Certainly it is often difficult to determine whether a given case is one of primary portal cirrhosis with secondary enlargement of the spleen or of primary splenic enlargement with a secondary cirrhosis. Perhaps the nomenclature depends, to a certain extent, on which conditions the diagnostician discovers first, that of the liver or the enlarged spleen.

The classical description of the portal cirrhosis of Laënnec, that is, the hob-nail or gin liver, has given rise to a widespread belief that in portal cirrhosis, at least, the liver is small. This is true only of the Laënnec type. It will be found that as many cirrhotic livers are enlarged as are atrophic. We cannot accept the view which is sometimes held that greatly enlarged livers, often containing quantities of fat, later become atrophic. Atrophic cirrhosis is evidently a response more characteristic of the drinking of gin and other spirits, or of pepper excess as

seen in India, also of those poisons carried to the liver from the spleen, as seen in the splenic anemias. The beer drinker is more liable to have a so-called hypertrophic portal cirrhosis, much of the size being due to deposits of fat in the liver. A large proportion of the portal cirrhoses that we have seen were non-alcoholic in origin. Two causes of ascites are frequently mistaken for the portal cirrhosis.

The ascites which attends chronic proliferative polyserositis (Concato's disease) is often confused with the ascitic stage of portal cirrhosis. On opening the polyserositic abdomen in the typical advanced case the peritoneum is found thick and white, and there is great shortening of the intestinal mesentery. The otherwise normal liver and spleen are encased in fibrous coverings. Fluid will usually be found in both pleural cavities, and Pick's syndrome, the result of coincident pericardial effusion or adhesions, is often present. In Guy's Hospital, Fagge found ascites once as the result of Concato's disease to three times as the result of cirrhosis of the liver. Thrombosis of the portal vein and its tributaries, as shown by Warthin, is also a not infrequent cause of chronic ascites and splenomegalia.

Until recently, biliary cirrhosis has been confused with hemolytic icterus, in which disease the enlarged spleen, for some unknown reason, destroys an excess of red cells, causing hematogenous jaundice. The liver becomes enlarged, partly as a result of hyperplasia of the cells, a work compensation, although there is sufficient cell-irritation to cause the deposit of a certain amount of connective tissue. The confusion between hemolytic icterus and biliary cirrhosis is still further increased by the fact that the bile in the former condition becomes viscid and there is a tendency to the development of gall-stones with the usual secondary biliary infections. More than 60 per cent. of our patients with hemolytic icterus have had complicating gall-stone disease and a number of these have been under eighteen years of age. Many of our patients with hemolytic icterus have had gall-stones removed with, of course, failure to relieve the icterus, the relation of the enlarged spleen to the symptoms being unsuspected. The so-called "crises" are often dependent on acute exacerbations

of associated gall-stone infections, and we have seen a number of patients with primary hemolytic icterus and secondary biliary cirrhosis in whom this association was noted. Chronic pancreatitis is often associated with these two conditions, dependent on the biliary infection. In such cases the spleen must be removed to cure the hemolytic icterus and the gall-stone disease must be relieved by operation, before the patient can be cured. In passing, I might say that in my opinion Hanot's cirrhosis has no pathologic or clinical basis. To a large extent, the disease so designated has been either hemolytic icterus or biliary cirrhosis, or a combination of the two conditions.

Effect of the Removal of the Spleen. It seems probable that when there is great enlargement of the spleen with the cirrhoses, the removal of the spleen may, by cutting off the source of much blood, so reduce the portal circulation as to bring it to a point where the cirrhotic liver can carry on its function, or the measure of improvement may come about by preventing those irritants, ordinarily filtered out in the spleen, from reaching the liver. Probably both are factors as in splenic anemia.

In our series of 52 splenectomies for splenic anemia there were a considerable number in which the liver showed portal cirrhosis. In five advanced cases of this type the ascites completely disappeared after splenectomy, and the patients have gained so greatly in strength as to be said to be cured, and have been able to work for a number of years. When we consider that the splenic vein under normal conditions is about one-sixth the diameter of the portal vein, and that in the enlarged spleen the vessels are correspondingly increased in size, it will readily be seen that the removal of the spleen in suitable cases affords a quick and certain method of relieving the portal circulation.

I have removed the greatly enlarged spleen in 6 cases of portal cirrhosis; two of the alcoholic type. One patient died too soon after the operation to show benefit, but the other 5 were very greatly relieved. As the operation of splenectomy, which prevents the blood from reaching the portal vein, is not one of great difficulty, it would seem to be even superior, in suitable cases, to the Talma-Drummond-Morrison method of diverting the blood

from the portal to the systemic circulation through the venous compensatory channels of Sappey.

The relief of the portal circulation by reducing the amount of blood which enters the liver may also be readily accomplished by the ligation of the inferior mesenteric or superior rectal vessels. A small incision is made through the peritoneal covering of the right side of the sigmoid mesentery and the vessels are doubly ligated and divided, with resuturing of the peritoneal incision. Considerable experience in such ligations, made in connection with permanent colostomy as the first step of a two-stage removal of the rectum for cancer, has shown that an immense collateral circulation is established through the middle and external hemorrhoidal vessels, and that the bleeding at the second stage, done two weeks later, is so greatly increased as to become troublesome. The coronary arteries of the stomach could be ligated safely, but in the cirrhoses this procedure might increase the ever-present danger of gastric hemorrhage.

We have done the Talma-Drummond-Morrison operation twenty-eight times with four operative deaths. Eight of the patients have died at various dates following operation; the remainder have been more or less benefited; five report their condition as good. Various technics have been employed. In a few cases subcutaneous silk drains were placed with one end entering the peritoneal cavity. In two the internal saphenous vein was employed in a similar manner. All in all, we have found that the easiest and safest method is to draw the omentum up through the peritoneum into the incised rectus muscle, suturing it in that position, and closing the fascia carefully over it. On several occasions we have gone down a second time in the vicinity of the previous operation, with a view of increasing the omental attachments, and have found such extensive compensatory circulation, almost entirely venous, that we were obliged to desist, and even with difficulty controlled the hemorrhage. The Eck fistula, which diverts directly from the portal circulation to the vena cava, while occasionally successful experimentally, has as yet no practical value.

Bilary cirrhosis dependent on infections from gall-stones will

usually be found complicated by chronic pancreatitis and enlargement of the spleen. The remedy which suggests itself is removal of the gall-stones and drainage of the biliary ducts. The operation should be done as early as possible before extensive secondary duct infections occur, leading to deposits of calculi in the various liver ducts, such as are occasionally found in the terminal stages of the disease. The type of biliary cirrhosis which depends on chronic infection, resulting in a reduction in the lumen of all the ducts of the liver, presents a difficult problem. In several instances, when it seemed indicated, prolonged drainage of the gall-bladder was instituted. This apparently has been of benefit to the patient and suggests that the source of bacterial infection was in the gall-bladder. We have, in selected cases of this kind, made a cholecystogastrostomy or a cholecystoduodenostomy, as they are equally as efficient and less troublesome to the patient than the cholecystostomy. Some of the patients have been greatly benefited; but as a considerable percentage have had coincident chronic pancreatitis which may have interfered with common duct drainage, some part of the improvement may have been derived from relief of this interference.

I have removed a large spleen in five instances in which there was associated advanced biliary cirrhosis, and the results have been extraordinarily good, although none of the patients can be said to be cured. Whether the splenectomy, by reducing the amount of work, acted as a relief to the disturbed liver-function, or whether it was the means whereby bacteria, reaching the blood stream from focal infections in the body, were diverted from the liver, I am unable to determine.

In conclusion I would call attention to splenectomy and similar procedures as a ready means of reducing the portal circulation for the purpose of relieving the subnormal liver of its overload.

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DISCUSSION

Dr. John Bapst Blake, Boston:

I should like to ask if removal of the spleen diminishes the hepatic circulation? If the spleen is not there the blood is not filtered through it and one cannot therefore see how the removal of the spleen diminishes the amount of blood going to the liver.

SPASTIC ILEUS (SPASMODIC INTESTINAL OBSTRUCTION)

By LEONARD FREEMAN, M.D.
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An ordinary classification of obstruction of the bowels is into mechanical and dynamic, the latter including both muscular spasm and muscular paralysis. Considering, however, the real meaning of the word dynamic, it is more accurate to adopt three divisions, mechanical, dynamic and adynamic, as is done by Ashhurst and others, and it would probably be better still to speak simply of mechanical, paralytic and spastic ileus, which would admit of no misinterpretation.

Obstruction from spasm of the constrictor muscles of the bowel is usually put down in text-books as a rare occurrence when it is mentioned at all. If it received the attention it deserves it would undoubtedly be recognized more frequently. A little reflection upon the permanent character of mechanical obstructions can hardly fail to convince one that most cases of enterostenosis recovering spontaneously, or under the use of eserine, belladonna, electricity, etc., are really spastic in origin.

Enterospasm as a cause of serious obstruction was first emphasized by Haidenhain about twenty years ago. Many surgeons at once denied its existence, but since then a sufficient number of cases, supported by operative findings, have been reported to establish its actuality beyond question. In fact, its possibility should be evident from the frequency of pyloric spasm and that of the lower end of the esophagus, to say nothing of spastic contractions of the small intestine occurring in lead-poisoning,

tabes dorsalis and hernia. The literature of the subject is comparatively meager, an occasional article appearing here and there in American and foreign journals. In 1902 Langenak collected 12 cases, only 2 of which had been proved by operation, and even as late as 1915 Matthews could find but 21 reports fully substantiated by laparotomy or by autopsy.

Spastic ileus is due to a spasmodic muscular contraction of a portion of the intestinal tract. It may affect either the small or the large bowel, or both—in one place usually or possibly in many places. It generally includes a few inches of the gut only, although at times a considerable length is compromised. A common location is the lower portion of the ileum. The typical appearance is striking and unmistakable. A section of gut a few inches in length is contracted to the limit, rendering it white, bloodless and so firm that it often may be picked up by one end and held horizontally without bending. The contracted part does not merge gradually into the adjacent bowel but stops abruptly at either end, the rest of the intestine remaining normal (see illustration); but if the trouble lasts long enough the proximal bowel dilates, as in any other form of obstruction. The spasm frequently persists after the abdomen is opened, although it may disappear, and it is sometimes found even at autopsy.

Some surgeons (Körte, Wilms) insist that there must be a coincident paralysis of the remaining bowel or the spasm would be overcome by peristalsis; but if this were true it would be hard to account for the instances in which invagination occurs, as there would be nothing to impel the intussusceptum into the intussuscipiens. In this connection it should be noted that local spasm is probably the first stage of intussusception (Nothnagel), and many supposed cases of this difficulty that recover spontaneously are possibly instances of spasm only. When invagination occurs it is facilitated by the fact that the bowel stiffens and elongates as it contracts, thus forcing itself into the distal segment.

The origin of spastic ileus is involved in considerable obscurity. There are those who wish to attribute it to local causes—irritation of the peritoneal or mucous surfaces, contusion of the external

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abdomen (Trendelenburg) or even severe muscular strain. Others prefer to assume that the sympathetic system or the vagus is the seat of the difficulty, while still others lay the blame upon the central nervous system alone (hysteria, neurasthenia, tabes dorsalis, etc.). Payer discards the nervous system altogether, at least in postoperative cases, and insists that the trouble is due to emboli originating in traumatic thrombosis of the omental and mesenteric vessels.

No one of these theories will fit all cases, just as no single explanation will cover all instances of muscular spasm elsewhere.

The local irritation theory is based upon the existence of the sympathetic plexuses of Meissner and of Auerbach in the submucosa and between the muscular layers of the bowel, which are supposed to be very susceptible to irritation of the mucous lining. It is supported by experimentation on dogs, and in the human such spasms have been observed in connection with the presence of gall-stones, ulcers, round-worms, incarcerated herniæ and also bacterial and other poisons. The contraction has even been seen to shift from one point to another, with movement of the foreign body. This solution of the problem seems less clear, however, when we take into consideration the multitude of operations performed in which the bowel is traumatized in every conceivable manner, and also the vast number of indigestions continually taking place without diminishing the rarity of spasmodic ileus. In addition, if irritation is assumed to be the cause it does not explain why opening the abdomen and handling the intestines should relieve the spasm, as it often does, or why spasm should take place with comparative frequency in breast-fed infants. It is likewise difficult to understand how a traumatic lesion of one part of the intestinal canal can produce spasm in another more or less remote portion, as has been observed by Haidenhain, Miller and others; and also why it should occur at times from twisting of the pedicle of an ovarian tumor or pinching of a testicle within the inguinal canal. Such phenomena are more readily explained by the assumption of a reflex nervous action. Hence, if direct irritation is to be considered we must assume some other factor,

such as a lack of local or general resistance, which, as in so many other conditions, does not explain much.

Beyond its mere possibility there is not much to support the assumption that the trouble originates in the sympathetic or in the vagus. To be sure, both these nerves, especially the former, supply the digestive tract, but this does not make it clear why they should cause a local spasm; in fact, if either one of them were at fault it would seem more likely that contracture of an extensive segment of bowel would result instead of a few inches only. This same objection also applies to the central nervous system.

In support of the theory of central origin it is argued that spastic ileus is found in neurotic and hysteric individuals, Hawkins stating that "its dependence upon the mental state is not to be doubted." While this is probably true to a certain extent, it may not mean more than that such people have a nervous system which responds easily to stimuli; and in addition, a number of cases, including my own, have been reported in infants too young to be accused of hysteria or a "mental state" of any kind.

Payer's embolic theory can be made to apply to but few except postoperative or traumatic cases with injury of the omentum, and then it is supported by comparatively little direct evidence.

Hence, the best we can say at present is that spastic ileus is a reflex nervous spasm of the bowel, due to some irritation in the immediate vicinity, or in some more remote portion of the abdomen or the body, and often determined by an especially susceptible condition of the local nerves or the central nervous system. Why it should occur in a few individuals and not in many others, and why it should usually affect a small section of the bowel only, we are not in a position satisfactorily to explain.

It is important to know that spastic ileus may follow any sort of abdominal operation, either immediately or a number of days subsequently. That it also may occur after operations near to but not within the peritoneal cavity seems to be shown by a case of my own in which a right nephrectomy was performed for

pyonephrosis in a man of nervous temperament. The appendix had been removed some two weeks previously, and the gall-bladder, stomach and other organs examined and found to be normal. The patient did well for four or five days and then suddenly developed an extremely severe colicky pain near the umbilicus, accompanied with nausea and pale and clammy skin. Repeated enemata failed to produce either gas or fecal material. The temperature was normal and the pulse remarkably slow (this slow pulse has been emphasized by Haidenhain, who thought it might be due to irritation of the vagus). The attack lasted for more than twenty-four hours, slowly disappearing under the use of morphin.

Aside from other considerations, it is useful to realize that spasm may cause intestinal obstruction, because it helps to explain those cases in which the abdomen is opened and nothing is found. If we are able to say beforehand that an ileus may be due to spasmodic contracture a possible postoperative embarrassment may be avoided, and armed with this defence, we may be encouraged to operate earlier, thus avoiding dangerous delay.

The symptoms of this imperfectly understood trouble are always those of intermittent obstruction of varying intensity and duration. Some instances are so acutely severe, with vomiting, obstipation, shock, feeble pulse, leaky skin, etc., that death may rapidly occur; while others merely give rise to occasional abdominal pains, during the course of weeks, months or even years, without the development of more serious results than recurrent constipation. Between these extremes are a multitude of obscure cases that may tax the diagnostic ability of the surgeon to such an extent that many escape detection or are confused with chronic appendicitis (Hawkins) or other troubles.

It is seldom easy to differentiate between spastic and mechanical ileus, except in manifestly hysteric individuals, although the symptoms of spasm are often less severe and are apt to occur intermittently, which should arouse suspicion. In acute cases, where an immediate decision is demanded, it should always be made in favor of the mechanical form for fear of dangerously delaying an operation.

If spastic ileus could always be recognized the treatment would be comparatively easy, especially in the less severe cases, consisting principally in the administration of such antispasmodic remedies as morphin, atropin, chloral hydrate, the bromides, etc., together with hot fomentations and enemata of various kinds. If the symptoms are, however, at all urgent one should not dwell upon the refinements of diagnosis but proceed at once to operation. Delay is apt to be fatal if the obstruction is mechanical, and might even be so if it were merely spasmodic. When a spasm is found to be the cause of the obstruction experience seems to show that considerable reliance can be placed upon its disappearing while the abdomen is open or shortly after it has been closed. Why this should occur it is difficult to explain. It may be due to the mere opening of the peritoneal cavity or to the coincident handling of the bowel. We know it is not the anesthetic, because the spasm often persists throughout the operation in spite of profound anesthesia. Hence, if the patient is in reasonably good condition one may perhaps venture to close the abdomen, as has often been done, trusting that the spasm will disappear, from the combined effects of the operation and the subsequent administration of antispasmodics. But if the patient is in bad condition, with regurgitant vomiting from a paralyzed bowel, a poor pulse, subnormal temperature, etc., it will be necessary to obtain more certain relief, which can be done by establishing a fecal fistula above the obstruction, although even this may not suffice. (In a case reported by Pankow such a fistula had to be left open for two months, owing to persistence of the spasm.)

Anyone who has operated in spastic ileus must have been tempted to resect or short-circuit the contracted portion of bowel, and I believe this would occasionally be justifiable, in severe cases at least, because the risk of doing harm is but slight and the ultimate results of the let-alone policy have been unsatisfactory, owing to a tendency to recurrence. There is, however, no precedence for such a radical procedure, and there can be no certainty, with our present knowledge, that the spasm might not recur elsewhere.

The following is a report of a typical instance of spastic ileus occurring in a breast-fed female infant about six months old: After remaining well for the first two weeks after birth an intestinal indigestion occurred, with a moderate amount of mucus in the stools. Although this soon subsided the colicky pains accompanying it persisted in spite of medicinal and dietetic treatment administered by Dr. J. W. Amesse.

The pains were peculiar in that they came in spells at irregular intervals, lasting from a few minutes to many hours. Between the attacks the patient was well and happy for hours or even days at a time, with normal stools, digestion and appetite. Then, without apparent cause, the abdomen would become rigid, the lower limbs draw up and the patient scream and roll about in agony. There was no vomiting, no diarrhea and no rise in temperature. Neither fecal movements nor expulsion of flatus could be obtained, so that abdominal distention would result if the attack lasted long enough. Repeated examinations revealed no abnormalities of the lungs or of the nervous or circulatory systems except a heart murmur which persisted for three weeks and then disappeared. A roentgen-ray picture of the intestinal tract, taken between the attacks with the aid of bismuth, revealed nothing.

I first saw the case, with Dr. Amesse, at the end of the fourth week of the disease. A tentative diagnosis was made of "partial intermittent intestinal obstruction, of unknown origin," and an exploratory laparotomy decided upon in spite of the tender age and weakened condition of the patient. This was performed, under ether, on December 22, 1917, through a right, median, rectus incision.

A careful examination was made of the contents of the abdomen, including the stomach, the large and small intestines, the liver, gall-bladder and the spleen. Nothing abnormal was found except a marked spasm of a segment of the lower ileum, about five or six inches in length, which was white, bloodless, contracted to the size of a slate-pencil and so rigid that it could be picked up by one end without bending. The peritoneal covering was normal and nothing could be felt within the lumen of the bowel. The

intestine above this narrow place was moderately dilated and that below slightly smaller than normal, the contracture ending abruptly at either extremity by a sharp wall.

Although it seemed sufficiently evident that the cause of the trouble had been discovered, it was not so clear as to what should be done. Entero-anastomosis and resection were both considered, but the condition of the patient was such that further operative intervention had to be abandoned and the abdomen closed. Although there was considerable shock a rapid recovery took place and the child was relieved of its trouble. For a month it remained well, gaining an average of a pound a week. At the end of this time an acute indigestion developed, with violent pains, the child dying within twenty-four hours, apparently from a recurrence of its original trouble (Dr. Amesse).

Summary. 1. The best classification of intestinal obstruction is into mechanical, paralytic and spastic. The last named is considered rare, but is undoubtedly more common than is generally recognized.

2. The causes of spastic ileus are not clearly understood, but they are probably various and act reflexly through the nerves.

3. In this form of obstruction a section of bowel, often only a few inches in length, becomes so firmly contracted that it is hard, white and bloodless, so that it often can be picked up by one end without bending.

4. The symptoms are intermittent. They may be acute, dangerous and severe, as in mechanical obstruction, or mild and chronic, merely causing occasional pains and constipation.

5. When there is doubt about the diagnosis it always should be made in favor of mechanical obstruction for fear of a mistake leading to fatal delay in operating.

6. Hence, the treatment is nearly always initiated by a laparotomy. When the condition is clearly understood, following an operation or otherwise, antispasmodics such as morphin, atropin, etc., can be administered.

7. Mere opening of the abdomen generally relieves the spasmodic contraction for a greater or less length of time, but it may return with possibly fatal effect.

8. Hence, it might be well to short-circuit the section of spastic bowel, although there is no precedent for this and no guarantee that the spasm might not recur elsewhere.

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DISCUSSION

Dr. J. C. Oliver, Cincinnati:

A few years ago a case of spastic ileus was brought to the Cincinnati Hospital as an emergency case. The symptoms were those of intestinal obstruction associated with severe abdominal pain; the abdomen was immediately opened and we found in the ileum this contracted condition described by Dr. Freeman. That was the first experience I had had with such a case and in investigating the cause I found very marked evidence of lead poisoning. Treatment directed to the condition of lead poisoning led to a complete recovery.

Just recently I have had another case which has been an exceedingly interesting as well as a worrisome one to me. The patient was a middle-aged woman who suffered from occasional epileptic attacks. A curious combination of circumstances was that her husband had been taken to the hospital with acute appendicitis and I had operated upon him, and the wife was staying in the hospital, when during the night she developed an acute attack of appendicitis. When the abdomen was opened we found a double hydrosalpinx and an acutely inflamed appendix. The tubes were removed as well as the appendix. She went along favorably for three weeks, but just about the time she was ready to go home she developed a double pneumonia. After recovering from this she developed a condition of spastic ileus. You could feel, by letting the hand rest on the abdomen, a segment of bowel contract; different segments at different times. By keeping the hand on the contracted area for a reasonable amount of time you could feel relaxation with disappearance of the masses. The first time this occurred she had a marked epileptic convulsion, and following this there was a period of a day or two when the spastic condition did not recur. The patient at first was free from vomiting, but later vomited and in the late stage of the condition, the intestines dilated and remained so. A laparotomy showed the entire intestinal canal dilated, but there was no obstruction. The gas was drawn off by the aspirating needle and the intestine returned to a normal condition, but she died a few days later. I am inclined to believe that in the fatal cases a paralytic ileus is found in the last stages.

Dr. Willy Meyer, New York City:

There can be no doubt that this is a distinct disease. I recall two cases that came to operation for ileus in which we found the exact condition described by Dr. Freeman. In the lower end of the ileum

there were three or four inches spasmodically contracted; in handling the gut and using hot saline applications we could see the spasm gradually disappear. The incision then was closed; the patients recovered.

I would further call attention to the sometimes splendid effect of atropin, $\frac{1}{60}$ grain, six to seven times repeated, with one hour interval, in these and similar cases.

Dr. Leonard Freeman, Denver (in closing):

The important thing, in my opinion, is not to make a diagnosis of spastic ileus in severe cases of intestinal obstruction. We should always assume that it is a mechanical ileus and thereby avoid the danger of overlooking a mechanical obstruction.

THE EXPERIMENTAL PRODUCTION OF PANCREATITIS IN ANIMALS AS THE RESULT OF THE RESISTANCE OF THE COMMON DUCT SPHINCTER

By EDWARD ARCHIBALD, M.D.
MONTREAL

ASSISTED BY

MR. BROW (MEDICINE, 1920)

A REVIEW of the literature concerning pancreatitis which has appeared in the last few years reveals the somewhat remarkable fact that, with a few exceptions, inquiry has busied itself with the pathology and the symptomatology of the disease rather than with its etiology, and it is also remarkable that observers have apparently been content to remain satisfied with the idea (well-founded, so far as it goes) that the cause of pancreatitis was closely connected with gall-stones and inflammations of the biliary tract. The anatomical relations of the pancreas with the biliary system, the relations of incidence between pancreatitis and cholelithiasis, the pathological changes in the pancreas, the intrinsic cause of death in acute pancreatitis and the functional diagnosis of the lesion—all these have been worked over, if not worked out, with an industry which has called forth a mass of literature much too large for the busy surgeon to command. Yet the very important problem of the etiology of pancreatic swelling—very important because without this key the door to rational treatment can hardly be opened—has been, if not quite neglected, at least inconsiderably handled.

In what follows I desire (1) to review, as briefly as may be,

the work hitherto accomplished along this line, and (2) to set down briefly an account of certain experiments and observations which seem to me to afford a reasonable explanation of the immediate cause of pancreatitis, whether acute or chronic, and also to suggest, as a corollary, the rational treatment.

What do we really know concerning the immediate cause of pancreatitis? With the exception of the few cases in which it is clearly the result of extension by contiguity from neighboring lesions, particularly gastric or duodenal ulcers, and of the few cases in which the mechanism first described by Opie has been active (of a gall-stone lodged in the ampulla of Vater damming back the bile into the pancreatic duct) we know very little that is positive.

The irritation, whatever it may be, that causes that swelling of the pancreas which we call, loosely, pancreatitis, whether bacterial, toxic, ferment or chemical, may conceivably reach the pancreas in one of several ways: by the blood or lymph vessels; by the bile ducts through their communication with the pancreatic ducts; and in this last instance either ascending from the duodenum or descending from the liver; by contiguous extension from lesions in the vicinity; or finally by direct importation through trauma.

The last two of these possibilities, being sufficiently obvious, we need not here discuss. It remains to consider what relative part is played by the other three modes, or rather, routes of possible attack.

1. By the Blood Stream. There exists a small amount of experimental evidence, and of clinical evidence, to show that an inflammation of the pancreas can be hematogenous in origin. There are, for instance, a few cases on record in which suppurative pancreatitis has been observed as a complication of general infections. Then, again, in such a disease as mumps, observers (Edgecombe, Simourin) have seen symptoms of acute pancreatitis in a few instances. Similarly in typhoid, influenza and in one case of mastitis (Dreesmann) has pancreatitis been found. Such clinical evidence is far from convincing as proof of the hema-

togenous origin of the disease. Now that we know how frequently the bile becomes infected, presumably through the liver, in generalized infections, it is quite as legitimate to suppose that the pancreatitis resulted by way of the bile tract as by the blood. Rosenow's recent work, indicating that bacteria can invade the wall of the gall-bladder by way of the blood, and that this localization is very often selective, is extremely suggestive, but even admitting this it is obvious that the causative factor in pancreatitis is not thereby explained. The infection of the gall-bladder can at most be regarded only as a first step, and not even a necessary step, in the production of pancreatitis.

2. By the Lymphatics. During the last few years a number of observers have been contending strongly that the pancreatic inflammation comes by way of the lymph and in particular from the infected gall-bladder and bile ducts. (Thiroloix, Maugeret, Arnsperger, Capelli, Deaver and Pfeiffer.)

Their arguments depend, in the main, upon two observations: (1) the finding of swollen glands immediately above the pancreas, in many cases of pancreatitis; (2) the demonstration of the anatomical communication between the lymphatics of the gall-bladder and the common duct with those of the pancreas.

To the writer, such arguments are difficult of acceptation. It is probably true that cancer cells, say in the breast, when their natural course to the axilla is blocked, may be transported or, as is more likely, may grow in lines by contiguity, backward against the lymph stream, and so produce metastases, apparently anomalous, in the other side of the chest wall or in the epigastric lymph routes. But does this occur in infections? Possibly it does, again by contiguous growth. But does it occur when there is a barrier of lymph nodes to pass? The swollen glands lying above the pancreas are surely more reasonably to be regarded as the result of the primary pancreatic inflammation than as the sign of infection coming from the gall-bladder which has broken through their guard. In cats in which I have caused a pancreatitis, these glands are found acutely swollen, obviously as the *result* of the pancreatic lesion. The demonstration of the pos-

sibility of infecting the lymphatics of the head of the pancreas from those of the gall-bladder or cystic duct is but small proof of the assumed fact that infectious material actually does take such a route. The lymph nodes draining any organ serve as a barrier to retrograde infection coming to that organ from elsewhere. It is most unlikely that the pancreas should be invaded by the lymph route. Not only is this the case, but a further argument is found in the fact that rarely is the pancreas the seat of a bacterial inflammation. Cultures from all but the frank abscesses, which are rare, are usually sterile, and sterile also from some of the abscesses. An infection coming by way of the lymphatics would usually, to judge from analogous experience, be bacterial in origin and in type, and pancreatitis would much more often than is the case be suppurative.

There has been in the literature of the last ten or fifteen years a great deal of work done concerning the dependence in a causal way of pancreatitis upon gall-stones and biliary infections, and it is perfectly clear, from statistics, that there does exist some relation of cause and effect between the incidence of gall-stones or bile infection and pancreatic swelling; and, moreover, that this relation is most clearly evident when the gall-stones are in the common duct. Opie's observation gave us the key to at least some of the cases. It cannot be doubted that sometimes a stone gets lodged in the ampulla and is just large enough to block the exit of bile, but not large enough to cover the opening of the pancreatic duct in the ampulla. The recorded instances in which this has been demonstrated are still few. Naturally, so many common-duct stones are successfully removed by operation nowadays, with the coincidence of a pancreatitis, which subsides, that the opportunity of such demonstration is rare, and it may be admitted that Opie's theory of causation is much more frequent than the recorded instances would indicate.

It may further be admitted (although this is not proved clinically) that large stones lodging in the ampulla may obstruct the free exit of pancreatic juice from the duct of Wirsung, and even induce local pressure ulceration, possibly with infection, and that

in this way, quite comparably with experimental conditions, a subacute or mild pancreatitis may be set up. The duct of Santorini may be insufficient to handle the whole amount of juice or may be anomalous in one way or another, and the consequent retention, just as in animals when the duct is ligated, may induce slight or even considerable reaction.

But admitting all this, the basis of which lies in purely mechanical interference with the outflow of the bile or of the pancreatic juice, there still remains a very large number of cases in which pancreatitis is present while gall-stones and even biliary infection are apparently conspicuous by their absence. It is certain that the cases of pancreatitis in which gall-stones are found in the common duct are in a large minority when compared with those in which they are either absent or are confined to the gall-bladder or cystic duct. These have hitherto remained without adequate explanation.

The experiments which I desire to record, rather briefly, were undertaken with the object of solving, if possible, the problem just indicated, and the work was started in the laboratory of experimental medicine, at McGill University, some seven years ago. The results of the earlier experiments, up to the middle of 1913, amounted to this: There exists a sphincter at the outlet of the common duct. It is able to withstand a large degree of pressure, amounting, in some cases, to five or six times that under which the bile is secreted in the liver. This sphincter is probably analogous with other sphincters in the body, and is, undoubtedly, regulated in its action by the condition of the duodenal contents in the various stages of digestion. It tends to remain closed during fasting. The application of hydrochloric acid in a strength of anything over 3 per cent. will, apparently, cause it to close, and sometimes even to go into spasm, so that it then resists a pressure of seven or eight hundred millimeters of water, such as would otherwise paralyze it. It was found possible in cats to flood the pancreas with a solution containing iron introduced into the gall-baldder at a water pressure of anything from three or four hundred up to seven or eight hundred

millimeters, the iron being found in the pancreas at autopsy by appropriate staining reactions. It was demonstrated that this flooding of the pancreas was due to the resistance of the sphincter of the common duct. These were the main factors elicited by our laboratory work in 1912 and 1913.

In January of this year I took up again the question of the causation of pancreatitis. It seemed natural to proceed from the point at which the experiments just described had been discontinued and to use bile instead of the iron solution. Almost at once the experiment was successful and we were able to produce an acute hemorrhagic pancreatitis, with death in half an hour. I may here briefly review the experiments concerned.

Cat No. 86. With a cannula tied into the gall-bladder and attached to a funnel with rubber tubing, there was allowed to run in ox bile which had been inoculated with Staphylococcus flavus and incubated for forty-eight hours. Pressure was immediately raised to 500 mm. (the normal pressure of bile as secreted in the liver is not much over 100 mm.). It was kept at 500 for forty-five seconds, after which bile obviously began to run through into the duodenum, as shown by the decreasing level in the funnel. The pressure was then lowered to 100; then raised to 300 for twenty seconds; then to 400 for twenty seconds; at this point the gall-bladder was found to become distended. It was then raised to 500 for thirty seconds and bile was now observed to run through freely into the duodenum. It was then lowered to 100 and the sphincter thus given a rest for one minute. It was then raised to 200 for two minutes, during which time there was no flow into the intestine; then to 250, and now the flow began into the intestine, but slowly, and in small quantities, about 2 c.c., going through in two minutes. The pressure was then lowered to 100 for thirty seconds; then raised to 250 again, when the flow began again in small quantities. It was then lowered to 100 for thirty seconds and raised to 300 for three minutes. At this level there was practically no flow. Particles in the glass cannula could be seen, sometimes going into the gall-bladder, at others being forced back; obviously there was inter-

mittent sphincter action. Pressure was now lowered to 100 for forty-five seconds, then raised to 350 for forty-five seconds and then without further lowering raised suddenly to 600. At this point the sphincter obviously gave way quickly and there was a free, rapid flow into the duodenum. After thirty seconds it was lowered to 100 and the operation was terminated. The whole operation lasted about twenty-five minutes and 80 c.c. of bile were used. Twenty minutes later it was noticed that the cat had stopped breathing, though the heart was still beating. Measures of resuscitation failed. Immediate postmortem showed a complete hemorrhagic pancreatitis from end to end, and I am able here to show you the specimen. The stomach was found to contain about 20 c.c. of the bile used, but it was not congested or abnormal. The duodenum was practically empty, the common duct was not dilated and there was nothing otherwise of note to be found. A culture was taken from the pancreas, with precautions, and a pure growth of the Staphylococcus flavus was recovered. Microscopic sections showed an enormous degree of hyaline necrosis, affecting primarily the center of the lobules and the parenchyma of the organ, but also, though to a less extent, the fibrous stroma. There was intense congestion, the capillaries being choked with blood even into the ramifications between cells; but evidence of hemorrhage into the tissues was wanting.

Here, then, we have a clear instance of sudden death from a fulminating pancreatitis within twenty minutes of the close of the operation, caused by the forcing of infected bile into the pancreatic duct through the resistance of the common-duct sphincter, without there being any other factor whatever in the causation of the lesion. The proof seems complete as regards the role which the sphincter of the common duct may take in the causation of pancreatitis.

In another experiment we were fortunate enough to reproduce the condition of subacute pancreatitis with death in sixteen days. The experiment was as follows:

Cat No. 84. March 30, 1918. Cannula in the gall-bladder. Ox bile inoculated with Staphylococcus aureus on March 27,

incubated for two days, and the third day kept at room temperature. The duodenum was opened for observation. The bile was run in at a pressure of 500 and quickly raised to 700. It appeared immediately in the duodenum. Pressure lowered to 100 and flow stopped. Then raised by 50's up to 250, when a little bile came through at the papilla at intervals; then raised to 450, at which a quiet, small flow became continuous. Lowered to 100, flow ceased; raised quickly to 700 and there was an immediate flow of bile through the papilla; lowered to 100, flow ceased; raised quickly to 400, which gave a slight flow, ceasing shortly, so that the sphincter was obviously holding; pressure was then kept at 400, the sphincter still holding, for from one to two minutes. This ended the experiment, the duodenum and the gall-bladder were closed, and abdominal wound sutured. About 25 c.c. of bile were used and the experiment lasted about twenty-five minutes. It was considered that the sphincter resisted well at 400 but gave way at 450. At the end of the experiment it was observed that all the pancreas in the neighborhood of the duodenal opening over a length of 1 to $1\frac{1}{2}$ inches was dark red, contrasting strongly with the normal pinkness toward the splenic and the lower duodenal end. The cat recovered well and seemed normal for some days. Toward the middle of the second week it refused food, but was not apparently suffering pain. On the morning of April 16 it was found dead but still warm. Postmortem was done within two or three hours. There was marked jaundice in the sclerotics and mucous membranes, which had probably, to judge from its depth, been present for several days, although the orderly had not noticed it. On opening the abdomen the whole abdominal cavity in front of the omentum and over the anterior surface of the liver was found to be covered with a layer of yellow mush, which could be scraped off very easily, but which, on the liver, left in places a rawish surface, indicating a several days' old inflammation. There was a small amount of thick yellow fluid in each flank. In the omentum there were a few spots of fat necrosis. In the mesentery, behind the pancreas, and especially close to the duodenum, these were quite numerous. The

pancreas was diffusely thickened, nodular and hard, being enlarged to abut twice its normal size. The thickening was diffuse throughout the organ, but was especially marked in the portion adjoining the entrance of the pancreatic duct into the duodenum. The pancreatic tissue looked pale, but also dull and opaque. The line of suture in the duodenum had broken open, but the opening was fairly well walled off by adherent omentum. There was no obvious obstruction in the common duct, but it is probable that the jaundice was due to obstruction at the site of the sphincter, either from pancreatic swelling or from spasm of the sphincter, inasmuch as the yellow mush, found free in the abdomen, was also found in the common duct and a considerable quantity of it in the gall-bladder, while the duodenum was absolutely empty, as also the rest of the small bowel. The escape of this yellow inspissated bile can only have occurred through the fundus of the gall-bladder, in which a ligature had been applied to close the cannula opening. This, however, was not clearly demonstrated, as the gall-bladder was cut open carelessly before this point was determined. The black silk ligature could not be found, but the bile track from the gall-bladder out to the dome of the liver was continuous, and the dome of the liver also showed the oldest lesions. The liver was yellow, pale and fatty, and one small abscess was found upon cutting it open. Death was probably due rather to this infective hepatitis and to the peritonitis, caused by the exit of infected bile, than to the pancreatitis. A smear from the peritoneal exudate, stained with methylene blue, revealed no pus cells but only amorphous débris, with many minute needle crystals.

The ox bile used was infected in other experiments with B. subtilis, with B. communis, with prodigiosus or with pyocyaneus.

In another small series, human bile, obtained from a cholecystostomy case in the Royal Victoria Hospital, was used. This was filtered through a Berkefeld filter to remove mucin, and sterilized in the autoclave before being used in the experiment. In one of these (Cat No. 90) the pancreas, upon chloroforming the cat seven days later, was found definitely thickened

over two-thirds of its extent, and sections revealed considerable necrosis without inflammatory signs, and with but little congestion. This, I think, corresponds to the condition frequently found at operation, in which the pancreas is only moderately thickened, without fat necrosis. The amount of necrosis in the pancreatic tissue is not so great as to cause sequestration and is probably gradually replaced, being aseptic, by fibrous tissue.

In another cat, No. 96, in which a normal solution of sodium taurocholate was injected into the gall-bladder without tension, the cat remaining well for two days and being then chloroformed, the pancreas was found slightly congested, though not enlarged or hardened, and numerous fat necroses were present in the fatty tissue above the pancreas throughout the length of the organ.

In others of this series no change in the pancreas was found. I need not review the other experiments in detail. In all about thirteen cats have been done.

It is unnecessary also, in this place, to go into detail concerning the histological picture of the lesions produced. Suffice it to say that they correspond accurately enough with those produced by the injection, with a syringe, of bile, of acids, alkalies, and other irritants, as carried out by Flexner, Pearce, Hlava, and a number of other observers, chiefly necrosis of the parenchyma, of the stroma also in severe cases, and congestion or even hemorrhage. They correspond also with the lesions found in the human. The main fact is that they have been here brought about through the action of the conmom duct sphincter, combined with some increase of pressure in the biliary system behind the sphincter, and with some change in the chemical composition of normal bile. I would suggest that this is the usual mechanism at work in the human cases, even when gall-stones are present.

If, then, we conclude that in man there must occur for the causation of pancreatitis an increased resistance of the sphincter, with increased pressure in the common duct, and a change in the constitution of the bile, one must ask how such a set of circumstances may be brought about. This is still unclear. It is probable that hyperacidity may have a good deal to do with it.

Symptoms indicating hyperacidity are frequently found in the previous history of patients with pancreatitis. Certainly the injection of hydrochloric acid into the duodenum will cause a spasm of the sphincter. In man we are still unacquainted, so far as I know, with the condition of the duodenal contents as regards the length of time which is necessary for neutralizing the acid chyme of the stomach. In alcoholics, anyhow, and in patients who have duodenal ulcers, it would seem probable that the duodenal contents might remain acid for some time, and in these two classes pancreatitis is rather frequent. Let me remind you here of three cases published by Dr. Mayo, in which acute pancreatitis was present, without gall-stones anywhere, but with, in each instance, a duodenal ulcer situated close to the papilla.

On the other hand it seems necessary for the production of pancreatitis that there should be some change in the composition of the bile, chiefly in the direction of a high concentration of bile salts and a diminution of bile mucin. It is here, probably, that the real effect of gall-stones, especially when associated with inflammation, comes in. In infected bile, it is pretty certainly not the bacteria acting in their infecting capacity that cause the pancreatic lesion, but rather the chemical change in the bile produced by the action of bacterial growth. This at least was strongly suggested by the work of Flexner, of Carnot, Hlava, and others, and the present experiments, in which sterile bile and a solution of sodium taurocholate caused the lesion equally with infected bile, tend to confirm this view.

In conclusion, I should like to say a few words about the bearing of these experiments upon treatment. With this conception of the action of the sphincter, I think it must be concluded that the cure of pancreatitis must lie in a prevention of any further retroinjection of bile into the pancreas. The damage already done to the pancreas will either be cured by the processes of nature, absorption, replacement, or sequestration, or, if too severe, will require a direct attack upon the pancreas itself. But to prevent recurrence or extension the cardinal point would seem

to lie in the prevention of any heightened pressure in the biliary system. This can only be done by a drain in the gall-bladder or in the common duct. Whether one should do a cholecystostomy or a cholecystectomy, with drainage of the common duct, is still a moot question altogether apart from the condition of the biliary passages and the situation of gall-stones in the individual case. Without pronouncing one way or the other in this matter, I would like to point out that in my opinion the essential thing lies in prolonged drainage, that is, prolonged prevention of any rise in pressure in the bile system. This is more completely done by a drain in the common duct than by one in the gall-bladder, and possibly explains, what we now are inclined to believe is the case, that a cholecystectomy gives better results than a cholecystostomy. But in either case, if the pancreas is materially affected, we must assume that nature will require at least three or four weeks, and often two or three months, of protection, in order to complete her repair work in the pancreas. I, therefore, adopt, as a rule prolonged drainage of bile, from one to three months, in all cases of pancreatitis save the very lightest. And I may add that a recent investigation into the late results of our pancreatitis cases at the Royal Victoria Hospital has brought out in a very striking way the value of a drainage kept up for over three weeks and up to three months; while on the other hand it has shown that a drainage of two weeks and less is followed by a large proportion of recurrences of the pancreatic attacks.

CHOLECYSTITIS

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While studying cholecystitis we are endeavoring to retain an open mind on a subject of much magnitude and on which many conflicting opinions are held as a result of the wide range of symptoms and sequelæ which may accompany and follow gall-bladder disease. The material on which this preliminary report is based will be published more in detail at a later date. It consists of an analysis of 210 cases of gall-bladder disease which we have compiled with laboratory reports, together with animal experiments.

We believe gall-bladder disease is an inflammatory process resulting from bacterial invasion. In culturing our specimens removed at operation we have obtained many strains of streptococci, not only from the lumen but also from the wall of the gall-bladder. We have also found Staphylococcus aureus in pure culture from the contents and in the glands along the common duct. We have also, on more than a few occasions, found an acute appendicitis associated with an acute cholecystitis where, as nearly as one can determine, the same strain of streptococci was recovered from the walls of the appendix and from the gall-bladder as well as from its lumen. We mention the streptococci because they are not a normal inhabitant of the gastro-intestinal tract to the same extent as is the colon bacilli, the latter of course

being the organism found in the greater number of cases both in gall-bladder and appendix disease. With these facts one must look farther than in the immediate neighborhood for the source of infection.

Let us for a moment briefly consider the various theories put forward regarding the ways of infection.

1. *Adami's*[1] *theory* of subinfection through the portal circulation by means of bacteria which gain access to the blood stream. The vast majority of the organisms no doubt are dealt with effectively in the liver, but some may retain their vitality and reach the gall-bladder and thus set up an inflammatory process.

2. *Ascending Biliary Infection.* That there are reverse peristaltic currents in the bile ducts there is no doubt, for carmine injected into the rectum will appear in the gall-bladder in a few hours. What part, if any, this plays in the production of the primary inflammation we are not at present prepared to say. However, we have an important clinical observation which may have some bearing on this point. A patient, six months previous to admission, had an ischiorectal abscess for which he refused surgical treatment and it ruptured through the skin. Three months later he developed an acute appendicitis, but as he had, since the beginning of his ischiorectal abscess, an increasingly irregular pulse his physician thought it wiser to treat it expectantly. On admission he was in a state of marked mental depression and suffering from attacks of biliary colic; he was very markedly jaundiced, with his ischiorectal abscess still draining. We thought his condition was due to gall-bladder infection and advised operation. His right iliac fossa was a mass of adhesions, with a small stump of his appendix in communication with the cecum. The pus was removed and the opening closed. The gall-bladder was thick-walled and very dark colored. Cholecystectomy was performed and during his convalescence no bile leaked from the stump of the cystic duct. In about five days his jaundice had completely cleared away. This is the fact which interests us most because it must have been caused by an inflammatory process in the common duct below the end of the cystic duct.

In other words, despite the intense jaundice he apparently had an acute cholecystitis and the removal of the septic focus allowed it to clear up. One would think that if ascending infection were a real factor he would have intense jaundice persistently until the common duct was drained.

3. *The Hematogenous Origin.* Rosenow,[2] in a paper published, has so admirably shown that this occurs that we can no longer doubt that it may explain the presence of various infections following remote febrile disturbances. Recently, we had in our wards a patient who had, one week previous to admission, a severe tonsillitis, and when examined in the hospital had an acute abdomen, with temperature of 103° F. Operation revealed both an appendix and gall-bladder acutely inflamed, covered with fibrin and from which streptococci were cultured. Such cases are not unique in our experience.

The Contiguity Infections—namely, where the gall-bladder is involved merely as an incident to some neighboring condition, such as a perforating gastric or duodenal ulcer. This type of infection does not particularly concern us here, however.

The first and third mentioned methods are the ones which appeal to us as the most likely. They also, as suggested by Detweiler,[3] may be associated. We have found a larger percentage of streptococci in our acute cases than we have in the chronic. In fact, it is rare to find anything but colon in a chronic gall-bladder condition; often in those exhibiting the greatest gross pathology and containing stones the cultures have been sterile. Is it not possible that the acute infective process is hematogenous in origin and that later a subinfection, through the portal circulation, with colon bacilli, occurs? These can grow more readily in a diseased gall-bladder and overcome the original infection, and then as they have been rendered less virulent by their passage through the liver, and as the gall-bladder recovers its powers of resistance to their presence in cholecystitis, adhesions, or a deformed gall-bladder, with or without stones, result. If such is true then most gall-bladder diseases are dealt with a long period of time after their original inflammation. In this

disease at present we are differing from our surgical idea of appendicitis. The patients are not urged to have operations when the gall-bladder conditions are first suspected, as they are in appendicitis, for the reason that the immediate danger to the patient is less in the latter disease.

Such logic must lead us then to subdivide the life-history of gall-bladder disease into various stages. These reach from the original infection to the time when the patient is driven to an operation for acute empyema or common-duct obstruction or malignancy, or some other such acute disaster. The following is suggested by Babcock:[4]

First Stage. It is in this stage of gall-bladder disease that we feel we have the greatest scope for improving our end-results, which in the not far distant past left a great deal to be desired from a surgical stand-point. Most of the patients in this category are obsessed with the idea that they have stomach trouble and form a population from which the various quack remedies for such a condition prove a lucrative source of revenue.

We feel certain that any surgeon of wide experience will agree with us in believing that the stomach is the source of pathological lesions in less than 10 per cent. of the instances in which the patient, and often the medical adviser, believe it to be at fault. Not that we believe the gall-bladder to be the sole reflex cause of gastric disturbance, but we feel very strongly that the reflex factor in such is not given the consideration due it in the vast majority of cases. Let us once and for all abolish from our nomenclature "acute indigestion," for who among us can accurately define that diagnosis and communicate its underlying gastric pathology? Then we have also records of cases, confined to bed on special diets for months with no improvement, cleared up when the gall-bladder has been dealt with. Again, we have many instances of a disturbance in bowel movements from obstinate constipation to mucous colitis. We have recently had six cases of the latter who have undergone all the usual non-operative therapeutic measures to combat it, with no relief. These cases have all been markedly benefited by dealing with the gall-bladder

pathology, and we feel will entirely recover as soon as the large bowel is able to repair the results of the chronic inflammation. The reason for such divergent symptoms being caused by one organ, we feel must be due to the difference in the infective organism. It is in this stage, too, where there is nothing to attract one's attention to the gall-bladder, that we have evidence of metastatic disease on the information derived from a questionnaire we are sending to our patients. It is very illuminating to find the number that are relieved of headaches, rheumatism, vomiting, etc., as a result of having their infective focus dealt with. Hence, at this time one has to make the diagnosis by a process of elimination rather than by symptoms directly referable to the gall-bladder itself.

Second Stage. In this stage we have symptoms directly referable to the gall-bladder region, the result of recurrent acute inflammations or the movement of calculi. At this time one has attacks of the typical colic usually attributed to stones, but which, however, may occur in the absence of stone. One can occasionally differentiate these colics clinically previous to operation. That due to stone comes on suddenly, is extremely severe and ends as suddenly as it came. The colicky attacks, the results of inflammation, come on more gradually and reach their intensity more slowly and are not of such violence as the stone colic and do not leave suddenly, but persist in a dull soreness for some time.

Third Stage. In this stage, unfortunately, in the past most patients have been subjected to surgical procedure, much to the discredit of the efficacy of gall-bladder surgery. Here we have our dangerous complications, such as acute empyema, perforating gangrene, common-duct obstruction, pancreatitis and let us not forget malignant disease. As aids in diagnosis our laboratory methods have failed us to a very great extent. We can obtain in stomach analysis all gradations from alkalinity to hyperacidity. The roentgen-ray plates in suspected cases of gall-stones at present have not proved of any great service so far as we have been personally concerned. We have had no direct experience with estimation of the cholesterol content in the blood as an

indication of stone, but in other hands it has not been of much help, and if our contention is correct—that it is an infective and not a metabolic disease—why should it be an aid?

Recently, Dr. Rolph[5] contributed a paper on urobilinuria in relation to gall-bladder disease. At present we cannot make a definite statement in regard to this, but can say that, rarely when it has been present, have we found normal gall-bladder, but in its absence we have very often found gall-bladder pathology. In other words a positive urobilin test in the great majority of instances indicates gall-bladder disease, but a negative test by no means rules it out.

The treatment is essentially surgical. The profession has long since given up the idea of dissolving the stones with drugs, and if it is an infective condition, as we believe it is, then it must be dealt with locally.

In regard to vaccine therapy. A series of experiments was conducted by the United States Medical Corps in order to determine the efficacy of vaccine in typhoid carriers. This was carried further on animals, with the conclusion that vaccine therapy had no definite result in improving the condition. Hence, when they are able to definitely deal with the specific organism, with no improvement, there is little hope in gall-bladder disease where there is a multiplicity of infecting bacteria.

In the past, gall-bladder conditions have really been treated from ten to twenty years too late, all medication previous to that being only for reflex symptoms; hence, it behooves us in the future to recognize and deal with the condition during the first stages which may last for from ten to twenty years.

In suggesting such a procedure we are again confronted with a new difficulty —namely, the ability to recognize a pathological gall-bladder in the gross at the time of operation; for here, you see, you have no stones, and unless there is a severe pericholecystitis there are no adhesions. Many of us in the past have felt chagrined when we operated for gall-stones and found none, with may be no adhesions, and failed to recognize any pathology about the patient, who then would turn up years later for some acute

surgical emergency in his gall-bladder. It may be interesting to you to have stated the grounds on which we base a diagnosis of pathology in the gross. In the first place stones are merely an incident in the disease. If there are pericholecystic adhesions there must have been an infection involving not only the wall of the gall-bladder itself but the surrounding structures, and it is hence obviously pathological. Then, again, we have the deformed gall-bladder resulting from a localized fibrosis. These are the easiest. Others may appear and feel normal, but on palpating along the ducts one finds enlarged glands. These we take as an evidence of gall-bladder infection in the absence of any duodenal pathology, and from the glands of such cases we have secured positive cultures.

Again, alteration in the color and thickness we have learned is the result of an inflammatory process which causes fibrin in the muscular wall and alters the circulation to such an extent as to markedly change the color from the normal pearly gray. These cases are all checked up by microscopic examination, and we have yet to remove a gall-bladder which did not show pathological lesions microscopically.

There is much discussion as to whether to drain or remove a pathological gall-bladder, and our attitude is, "Would you drain an infected or fibrosed appendix?" Now, would you? Provided of course that the condition of the patient or technical difficulties do not make it a hazardous procedure. This statement of course does not apply so directly to the common-duct obstruction from stone or some growth. Here the surgeon's skill and experience will determine which will be the more likely to relieve his patient. In chronic cases in which we remove the gall-bladder we are now, in selected cases, closing without drainage, using the technic described in a previous communication.[6] We have little fear from bile leakage in the chronic type, but in acute cases the virulence of the infection or hemorrhage from pericholecystitis may lead to the use of drainage.

Another great factor in leading us to do cholecystectomy is that we feel that while stones may reform, a large number of the

secondary operations where stones are found are really stones overlooked in a pouch so often at the neck of the gall-bladder, lying retroperitoneally and on top of the common duct. Such an oversight is impossible in removing the gall-bladder, because this pouch has to be dissected free before one can proceed.

Again, secondary operations on the gall-bladder in our hands have been nothing like as satisfactory, because of the adhesions which have formed; hence, let the diagnosis be made at a time when it is safe to deal with the existent pathology radically and for all time.

The histological findings in the specimens removed have largely been characterized by destruction of the mucous membrane in various degrees, from an erosion of it at the tips of the papillæ to a complete disappearance in the old chronic cases containing stones, the fibrosis and round-cell infiltration being in direct ratio to the amount of destruction of the mucous membrane.

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DISCUSSION ON THE PAPERS OF DRS. ARCHIBALD AND STARR AND GRAHAM

Dr. Stephen H. Watts, Charlottesville, Virginia:

I have been interested in pancreatitis for a number of years, and, like Dr. Archibald, I am rather inclined to think that infection is a secondary feature. In this connection I should like to mention three cases already reported before the Southern Surgical Association. These were cases of subacute pancreatitis which I operated under the diagnosis of gall-stones. At operation I found gall-stones, but I also found fat necroses, and on examining the pancreas I found it thickened and its limits poorly defined; in short, I found a condition somewhat suggestive of chronic pancreatitis. In all of these cases I drained the gall-bladder, but did nothing to the pancreas; one patient recovered and two died. At autopsy I found in both cases that the process had progressed or lighted up and that death was due to a marked necrosis of the pancreas, with extensive hemorrhage into the gland itself and into the peripancreatic tissues. I have seen nothing in the literature in regard to these cases of subacute pancreatitis which verge on the chronic and I hope some one will discuss this type of case. I believe that these cases of subacute pancreatitis with comparatively mild symptoms, in which the gland is considerably thickened, its limits poorly defined and with evidence of fat necrosis, require the same treatment as acute pancreatitis; namely, incision and drainage of the pancreas. Had I followed this procedure I might have had better results in these cases.

Dr. William J. Mayo, Rochester, Minn.:

I am very much interested in Dr. Archibald's paper, although I must confess to a great deal of uncertainty when faced with the condition he discusses. I have found pancreatitis of any type only in about 10 per cent. of operations for gall-stones. Much depends on the sense of touch. In all operations on the gall-bladder the pancreas should be palpated, and in this way some cases of subacute pancreatitis that have not been suspected will be discovered. Occasionally a rough pancreas feeling like an ear of corn with a suspicious tumor is found, and it cannot be determined by palpation whether or not it is in a cancerous condition.

Much of our earliest knowledge of acute pancreatitis was gleaned from work on the cadaver, and for a long time I supposed that a man having acute pancreatitis would die. I have, however, seen many

patients with acute pancreatitis recover spontaneously. I should hesitate to put a knife into the acutely infected pancreas except for a definite, localized condition. Just what good are we to get by incision of the pancreas or other similar organs when the condition is generalized? Deaver's work on this subject has been excellent. He has pointed out that there are two different kinds of ferment in the pancreas; first the lipase, which produces saponification of the fat or fat necrosis only if not infected. I have seen fat necrosis from acute pancreatitis in every stage of recovery; and second trypsin, which produces the hemorrhages because it acts on the proteins, which means the bloodvessels. I have seen acute pancreatitis with hemorrhage and at a later stage have opened such accumulations of blood, sterile and encapsulated, with resulting recovery if uninfected. We finally come to the cases of acute pancreatitis complicated by infection of a graver character, concerning which Dr. Archibald, by his experiments, will be able to teach us much. I have seen the pancreas slough and have lifted out what I thought was the whole organ, but as no diabetes followed and the patient recovered, evidently not all of the pancreas was removed. We do need and will get from such work as Dr. Archibald is doing, more definitely than has heretofore been possible, the knowledge of what happens to the pancreas. We will learn what really exists and not what each one of us, through his sense of touch, thinks exists.

Dr. Huntington has asked if I regard the opening of the pancreas as a serious undertaking. I should not want to say that I do because I have had few such experiences. It is surprising how much can be done to the pancreas. I remember an instance in which, in a hasty splenectomy, I also removed two and a half inches of the tail of the pancreas. No harm resulted. In another case I put a ligature around the splenic artery and vein; the vessels were atheromatous and cut through. I then included the body of the pancreas to back the ligature; the patient recovered. In another case of tumor in the center of the pancreas I removed two-thirds of the organ, sewed the two ends together and the patient got well. I would say, further, in regard to infections of the gall-bladder, that our first ideas of pancreatitis were of the cases in which the common duct went through the pancreas, causing jaundice, and in which it was necessary to drain the gall-bladder, then pancreatitis without jaundice; still we drained the gall-bladder whether or not there was obstructive jaundice. I shall tell you the story of a Rabbi who came to the clinic and who had his gall-bladder drained three or four times. Before coming to the clinic he was jaundiced. Eighty-three per cent. of the Russian Hebrews are

neurasthenic, and this must be taken into account. I had advised against further operation and dismissed him. He persisted in coming to the clinic, where he would fall on the floor and cry with pain; he frequently had attacks in the middle of the night. Morphin seemed of no avail. In self-defence I finally removed his gall-bladder and found a chronic cholecystitis, causing a chronic pancreatitis. He is now one of the most grateful patients I have ever had. If I had had good clinical acumen I would have recognized the condition. As long as his gall-bladder drained he got along all right, but when the fistula healed the symptoms would once more become acute. Removal of the gall-bladder stopped the recurrences of trouble.

To sum up: Patients having chronic pancreatitis without jaundice, dependent on gall-stones and infections, get well and stay well when the cause is removed. When the patient is jaundiced, cholecystoduodenostomy or cholecystogastrostomy should be done. For acute pancreatitis with fat necrosis and gall-stones the gall-stones should be removed with drainage. For pancreatic apoplexies with residual blood cysts the cyst should be evacuated and drained. For acute septic localized conditions evacuation and drainage should be done.

Dr. Archibald MacLaren, St. Paul, Minn.:

I feel quite sure that in these experiments Dr. Archibald has made a discovery. I do not know much about the pancreas, but remember one instance where, in operating upon a man whom I thought had an acute perforation of his stomach, I found no perforation but an indurated pancreas. I sewed him up tight; in a week or two he developed an abscess that was opened through the rectum, showing fat necrosis. Postmortem disclosed an acute duodenal ulcer, with acute pancreatitis.

Regarding Dr. Starr's paper, it was my intention this year to read a paper upon acute gall-bladder conditions, because during the past year I have lost four such cases. When I find a gangrenous and perforated gall-bladder it is my policy, as I understand it is also Dr. Starr's, to treat it as I would an acute gangrenous perforated appendix. It is, however, quite a different matter, because when you do a cholecystectomy you open up a large surface for infection of the under surface of the liver which becomes infected and the patient dies as the result of increased sepsis. I remember at this time I was calling on Dr. Jonas and I asked him his experience in acute gall-bladder conditions, and he said he had never removed an acute gall-bladder. I have done so a number of times, with good results, but because of my recent experience I doubt if I shall ever try it again. The cases that I have lost have been acute cystic gall-bladders, especially in very stout men and women.

Another thing about which I should like to speak is the frequently seen text-book illustrations. Cholecystectomy when the cystic duct is divided between two pairs of forceps and the gall-bladder is removed by stripping it from below. I consider this sometimes a dangerous procedure. I now usually prefer to strip the gall-bladder downward. A year and a half ago I had a case in which I tied the common duct, producing a stricture from which the patient later died.

To prevent the late leakage of bile from the stump of the cystic duct I have found that the best results have come following a double ligation of the cystic duct with ordinary catgut.

Dr. Edward Archibald, Montreal (in closing):

In reference to Dr. MacLaren's statements, I cannot help attributing his deaths as due to the sphincter. It does seem so easy to push bile into the pancreatic duct, so easy in cats at least, that I imagine a chronic or subacute pancreatitis may suffer an acute exacerbation of the disease at any time. I have had one such case. At any rate it seems to hold that it is important to keep the pressure in the biliary system down to a minimum during the course of healing of the pancreas, and this can be accomplished by a tube in the gall-bladder, or if you remove the gall-baldder, by a tube in the common duct.

Dr. F. N. G. Starr, Toronto (in closing):

With regard to the leak from a cystic duct, I believe Dr. MacLaren will have to change his technic. If the cystic duct is clamped across, then a suture carried beyond the end of the clamp between the duct and the artery, so that it will tie, will control the artery. Then two or three sutures right through the duct and around the forceps are put in but not pulled tight until the forceps are taken off, then the suture is retied and there is no leakage, as a rule. The only cases I have drained in the last six months have been the acute cases. I have become quite brave about closing the chronic cases and in only three or four instances has any leakage followed the removal of the gall-bladder. It is difficult to get in the proper line of cleavage when starting from above. An acute case embedded in the liver one would not attempt to remove because of the possibility of opening the gall-bladder during the process and infecting a large portion of the liver. The only case which I have lost during the past year was one which I had drained.

CONGENITAL HERNIA OF THE DIAPHRAGM

By WILLIAM A. DOWNES, M.D.
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Diaphragmatic hernia, congenital and acquired, occurs much more frequently than was formerly supposed. The diagnosis of this condition can be made with little doubt by means of the roentgen-rays. In the last few years many cases correctly diagnosed and successfully operated upon have been recorded in the literature, whereas according to Scudder, up to 1912 there were only 6 recorded instances in which the diagnosis of diaphragmatic hernia had been made previous to operation. This author states that nearly all cases prior to that date came to operation with the diagnosis of intestinal obstruction, which accounted for the high mortality.

The acquired or traumatic cases have been recognized more frequently than the congenital on account of the history and sudden onset of symptoms. In many of the congenital cases the condition is discovered accidentally in the routine examination of patients who come to the surgeon for the relief of symptoms suggestive of ulcer of the stomach, pyloric stenosis, intestinal obstruction, etc. Still others give no symptoms of the abnormality and die of intercurrent disease, the malformation being discovered at autopsy.

Congenital diaphragmatic hernias are classified as true or false, depending upon the presence or absence of a sac. The great majority of cases come under the latter group, the hernial contents passing directly through the diaphragm, either through a

dilated normal opening or through an abnormal opening, and lie free in the pleural cavity. This variety of hernia is much more common on the left than the right side, due in part, no doubt, to the position of the liver. The hernial orifice is usually located at the junction of the costal and lumbar portions of the diaphragm or at the junction of the costal and sternal portions, as these are the weakest parts. Hernial protrusion at the normal openings in the diaphragm is of rare occurrence.

In a series of 34 specimens of this type of hernia reported by Keith, only one was through a normal opening, and that the esophageal. As most infants born with diaphragmatic hernia die within a few hours after birth, very little opportunity has been afforded for a systematic study of the symptoms; a few cases, however, have been followed over a period of months or years. In those dying shortly after birth there is either complete absence of one-half of the diaphragm or a large hernial opening, which permits the greater part of the abdominal contents to enter the thoracic cavity. These infants suffer from dyspnea, become cyanotic and usually die in convulsions. The symptoms of the cases surviving the period of infancy vary according to the interference with the lung and heart by the viscera in the thorax, and according to the amount of constriction of the stomach or intestines at the hernial orifice, as shown by attacks of dyspnea with cyanosis, periodic attacks of pain, nausea, vomiting and loss of weight. There may be periods of weeks or months in which these patients are free from symptoms, during which time they gain in weight and strength.

The question arises whether some of these cases, in which the symptoms come on some months after birth, are really congenital or whether they are merely potentially so in that there is an unusually large normal opening through the diaphragm, or an undue weakness, and that the negative pressure of the thorax plus some possible trauma may not be the exciting cause. The physical signs will vary according to the number of abdominal organs in the thorax, the position of the patient, and, according to the state of the hollow viscera, whether filled with fluid or air.

Several cases have been recorded in which the full stomach situated above the diaphragm has been mistaken for a pyopneumothorax and aspirated, with a fatal result. In view of this danger all patients with obscure or unusual physical signs in the chest, especially with a long history, should be subjected to roentgen-ray examination before an exploring needle is introduced. Once the diagnosis of hernia of the diaphragm is established the question of operation arises. In the cases discovered accidentally, which give no symptoms, it is an open question whether to advise operation or not. A number of instances have been recorded in which a slight trauma has been followed by acute symptoms, necessitating exploratory operation, and a diaphragmatic hernia of undoubted congenital origin has been found, thus indicating that such a condition is a constant source of danger. For this reason these patients should be advised of the dangers and offered the benefit of an operation. Should acute symptoms arise in a known case of diaphragmatic hernia, immediate operation is indicated.

There is a difference of opinion among surgeons as to whether it is best to approach diaphragmatic hernia through the thorax or abdomen. It is claimed by some that the rent in the diaphragm can best be closed through the chest. While this may be true, especially for traumatic cases, this advantage is more than offset by the knowledge gained from an exploration of the abdominal cavity, and the ability to apply the correct operative procedure without delay or the added danger of a prolonged operation. Not infrequently the thoracic incision has had to be supplemented by an abdominal incision in order to restore the viscera to their proper positions or for the purpose of closing wounds of the stomach or intestines. Furthermore, in the congenital cases in which the hernia has occurred through a dilated normal opening, such as the esophageal opening, it would be impossible to correct the condition by approach from above.

The ideal result to be desired in a case of congenital diaphragmatic hernia is the restoration of the hernial contents to the abdominal cavity, with closure of the opening of the diaphragm.

This will be impossible in the cases in which there is complete absence of one-half of the diaphragm and in those in which the organs are too fixed to permit of mobilization. In the majority of recorded cases, however, it has been possible to restore the organ or organs to the abdominal cavity and close the opening in the diaphragm. In a few instances in which the opening was too large to close satisfactorily, the stomach or omentum had been made use of to complete the closure.

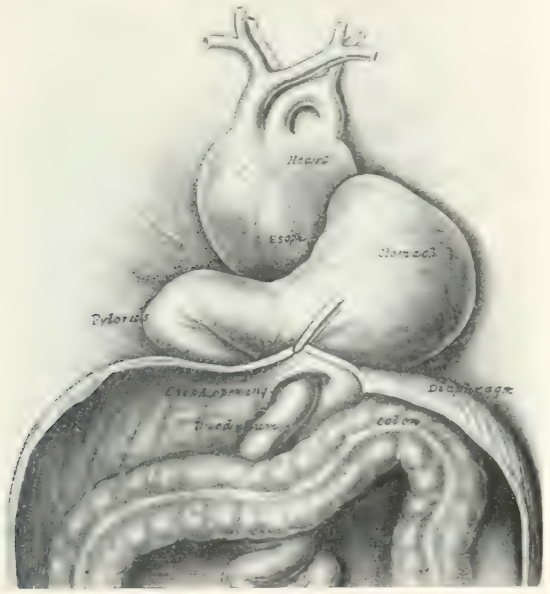

FIG. 1.—Congenital hernia of the diaphragm.

A case of hernia of the diaphragm, in which it was impossible or at least unwise to attempt reduction of the hernia, came under my care the past winter. The entire stomach and about three inches of the duodenum had passed through a dilated esophageal opening. Whether the condition had existed from birth or whether it dated from the onset of the symptoms, at twenty months of age, it is impossible to say. The stomach ran trans-

versely and rested immediately upon the upper surface of the diaphragm, extending slightly more to the left than to the right side of the chest. There was no hernial sac. The esophageal opening was slightly oval, being about two inches in its transverse diameter. Upon opening the abdomen it was noticed that the liver lay well to the left, and it was found necessary to divide the

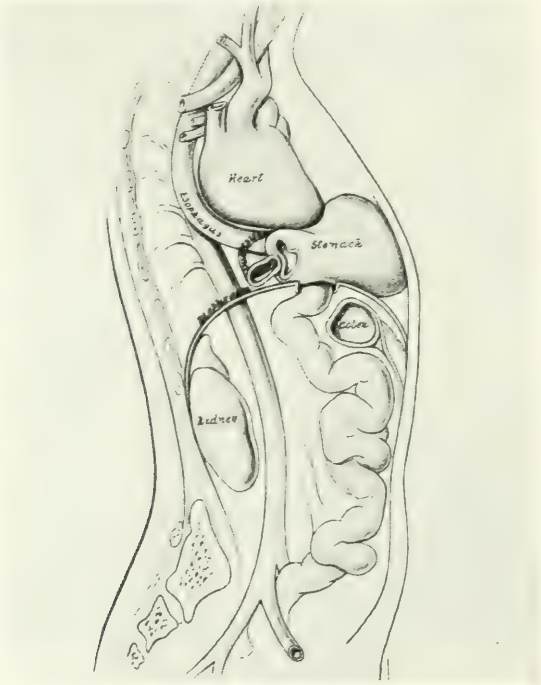

FIG. 2.—Diagrammatic sagittal section of congenital hernia of the diaphragm.

round ligament in order to expose the area usually occupied by the stomach. The duodenum could be seen passing up through the esophageal opening, but no part of the stomach was visible. The finger introduced into the thorax could just reach the pyloric end of the stomach posteriorly, and to the right. Gentle traction made on the duodenum failed to dislodge this portion of the stomach. As the child's condition was extremely poor it did not

seem wise to enlarge the hernial orifice for the purpose of separating adhesions which would have been necessary before further attempt at reduction could be made. Realizing the great danger of further effort to restore the stomach to its normal position, and the necessity for overcoming the obstruction at the pylorus, it was decided to perform a gastro-enterostomy. The

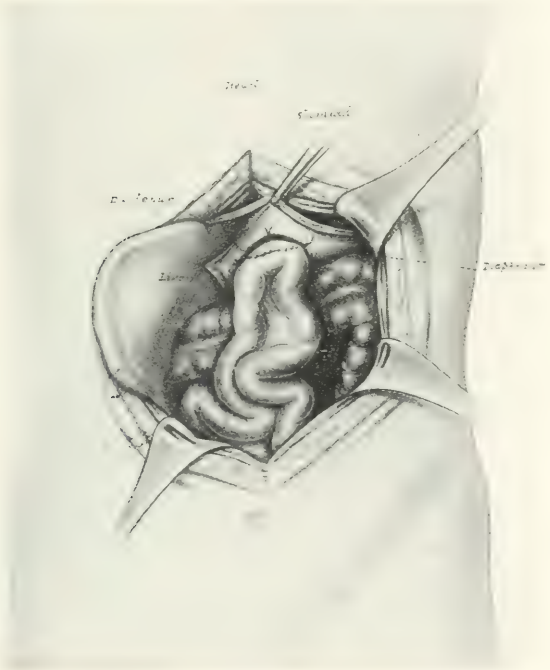

FIG. 3.—Anterior gastro-enterostomy through dilated esophageal opening in congenital hernia of the diaphragm.

greater curvature of the stomach was grasped with sponge clamps and a sufficient portion of the stomach wall for the purpose was readily drawn into the abdominal cavity. An anterior long loop gastro-enterostomy was performed. The gastrocolic omentum was split and the opening placed low down on the posterior wall of the stomach. In order to avoid the danger of the

intestine entering the thorax the stomach was anchored to the margin of the esophageal opening by three interrupted silk sutures just proximal to the anastomosis. Convalescence was straight-

FIG. 4.—Roentgenogram of N. C., 6 hours after second meal. Residue still present after twenty-four hours.

forward. Lavage was given daily for one week. There was no vomiting after the fourth day. Emphysema of the left side of thorax, extending from the costal arch to the clavicle, appeared on the fourth day, which lasted four or five days and then dis-

appeared, giving rise to no symptoms. The patient was discharged from the hospital at the end of five weeks, free from symptoms. At the present time, five months after operation, he has gained ten pounds in weight, eats and digests all sorts of food without vomiting or distress.

FIG. 5.—Roentgenogram taken four months after operation, twenty minutes after meal.

As has already been stated, many cases of diaphragmatic hernia have been discovered accidentally at an advanced age.

demonstrating that such a condition is compatible with health and life. Therefore, since the symptoms due to obstruction have been entirely relieved in this boy by the gastro-enterostomy, it seems fair to assume that he will continue to gain and develop

FIG. 6.—Congenital hernia of the diaphragm, six weeks after operation.

in a normal manner even though his stomach remains in the thoracic cavity. The history of the case is as follows:

N. C., aged seven years, was admitted to St. Luke's Hospital, December 28, 1917.

Chief Complaint. Vomiting and failure to gain weight. History dates back five and a half years, about which time he began to vomit immediately after taking food. The vomiting came on in periodic attacks, lasting two or three months, with free intervals of about the same length of time. This continued until three and a half years ago, when vomiting ceased entirely for a period of nine months. During the preceding two years, growth had been greatly retarded, but during the nine months in which food was retained, gain in weight and strength was rapid. About one and a half years ago vomiting recurred and has continued to the present time. The periods of remission, instead of being from two or three months, have been for only a few days at most. Occasionally he would vomit after one meal, but usually after every meal. Felt discomfort after eating, and recently, if he could not vomit, would force himself to do so by putting his finger down his throat. Vomitus would consist of food recently taken into the stomach, and would vary in amount. Was breast-fed until two years of age. Severe convulsive seizure when one and a half years old, and at two years of age was dropped down one flight of stairs. Vomiting attacks began at some time between these two incidents.

Physical Examination. Poorly nourished undersized male child. Chest of peculiar shape, very long and narrow. Expansion poor. Percussion note is good anteriorly, although liver dulness is very high; cardiohepatic angle is obliterated. Posteriorly, liver dulness reaches to four-inch space. Apex beat of heart is in four-inch space, just inside the left nipple line. Heart appears to be enlarged to the right. Stomach tympany obscures dulness on the left. Abdominal examination negative. Weight, $27\frac{1}{2}$ pounds. Tuberculin test negative. Provisional diagnosis on admission: cyclic vomiting.

Roentgen-ray Examination (Le Wald): Demonstrated stomach to be above the diaphragm. As part of the bismuth meal was vomited, emptying time could not be accurately determined, but was shown to be very slow. Bismuth enema demonstrated the colon to be of normal size and location.

Diagnosis. Diaphragmatic hernia (stomach).

Operation. January 4, 1918. Anterior gastro-enterostomy. Intratracheal anesthesia (Luke). Median abdominal incision extending from ensiform to umbilicus. Liver situated nearer median line than normal. It was necessary to divide the round ligament in order to expose the area usually occupied by the stomach. The duodenum was seen passing through the dilated esophageal opening, but no part of the stomach was to be seen. Finger inserted through the dilated opening located the stomach entirely above and resting upon the diaphragm. Traction upon the duodenum failed to dislodge the pyloric end of the stomach. In view of the very poor condition of the child it was thought best not to attempt to restore the stomach to its normal position but to perform an anterior gastro-enterostomy through the dilated esophageal opening. This was easily accomplished by drawing the greater curvature of the stomach partly into the abdomen. The jejunum was brought forward over the transverse colon and the anastomosis made about sixteen inches from the duodenojejunal junction. Stomach wall was anchored to the margin of the esophageal opening. Uninterrupted convalescence. Discharged symptomatically cured, February 16, 1918.

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A CONSIDERATION OF 8589 CASES OF HERNIA TREATED BY RADICAL OPERATION FROM 1891 TO 1918, WITH SPECIAL REFERENCE TO METHODS OF OPERATING AND END-RESULTS

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AND

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In order to study the merits of the surgical treatment of hernia it is essential to consider a large number of cases which have been operated upon. We have therefore collected all of these cases operated upon at the Hospital for Ruptured and Crippled since 1890 and the cases operated upon outside of that institution by Drs. Coley and Hoguet. The total number of cases under consideration is 8589. Of these, 6090 were operated upon at the Hospital for Ruptured and Crippled by Drs. William T. Bull, William B. Coley, John B. Walker, William A. Downes, C. G. Burdick, D. H. M. Gillespie and J. P. Hoguet. Of the remainder 1904 were operated upon by Dr. Coley and Dr. Downes, and 595 by Dr. Hoguet in hospitals other than the Hospital for Ruptured and Crippled. By giving the details of this large number of cases we believe we can demonstrate the efficacy of certain operative methods of treatment in certain types of hernia, as in all these cases a certain very definite operative technic was closely followed by the operators mentioned above. As can be seen from the accompanying tables, all types of hernia are included in the series and the patients were operated on at all ages, so that in every way the series is very wide in its scope. Great efforts have been made

to keep in touch with patients after operation. A large number report back at certain regular intervals and postal card inquiries are addressed to all at yearly intervals. We therefore think that we have traced a large number of the recurrences that have occurred among our cases.

Lack of space will not permit any reference to the older methods of operation for the radical cure of inguinal hernia, which were largely abandoned with the advent and early adoption of Bassini's method in 1890 and the years immediately following.

Of the various methods brought out since 1890 the majority have been more or less modifications of the Bassini method, and the more they have departed from the underlying principles of Bassini's method the less satisfactory have been the results. The Halsted operation, originated almost simultaneously with, though independently of the Bassini method, resembling it in the main features—the transplantation of the cord and suture of the internal oblique muscles to Poupart's ligament—while a great improvement on the methods which preceded it, had certain disadvantages which did not attach to the Bassini method, and it soon gave place to the typical Bassini operation.

Among the other methods which came into vogue shortly after the Bassini method, and which proved so efficient that they are still regarded as methods of choice by many surgeons at the present time, may be mentioned the so-called Ferguson method (Chicago) and the Wyllys Andrews method. Both of these methods closely resemble Bassini's method in many respects, the Ferguson method being practically identical with the Bassini method, with the step of the transplantation of the cord omitted. In the Andrews method not only the transplantation step is omitted, but a special method of applying the overlapping principle originally outlined by Championnière is made use of in closing the canal.

All of these methods embody the main principles of the Bassini operation—namely, the long external incision parallel with Poupart's ligament over the center of the inguinal canal, with free splitting up of the aponeurosis of the external oblique. This

latter important step for the first time made it possible to expose clearly the internal ring and permit complete removal of the sac at or beyond its neck, thereby obliterating any funicular process of peritoneum which might favor the early recurrence of the hernia. The second important principle of Bassini's operation is also included in these modifications: The suturing of the internal oblique and sometimes the external, to Poupart's ligament. The transplantation step was believed to be an unnecessary part of the technic and of little value, and therefore omitted.

Good and even excellent results were obtained by many surgeons who adopted these modifications of Bassini's method.

We think it might be wise to give a brief description of the exact technic of the different operations as performed by us:

Inguinal Hernia Indirect. 1. An incision $2\frac{1}{2}$ to 3 inches long (or 3 to $3\frac{1}{2}$ inches in adults) is made parallel with Poupart's ligament and about $\frac{1}{2}$ inch above it, so that the lower end of the incision comes directly over the center of the external ring.

2. The aponeurosis is slit up a distance of $2\frac{1}{2}$ to 3 inches in the direction of the fibers; in doing this it is important that the director should be withdrawn and the aponeurosis cut very carefully, so as to avoid severing the ilio-inguinal nerve which is frequently sacrificed at this step.

3. The aponeurosis is dissected well back on the inner side toward the rectus muscle, giving a full exposure of the internal oblique muscle. On the outer side the aponeurosis is dissected until Poupart's ligament is exposed to the pubic bone.

4. The sac and cremaster muscle just over the canal and above the external ring are seized with a pair of thumb forceps and lifted up and the muscular fibers pushed aside by means of a pair of blunt-pointed curved scissors. The white tissues of the sac are thus quickly exposed and held by a pair of artery clamps in the left hand, and with the thumb and fingers of the right hand the cremaster muscle is quickly and easily dissected from the sac and cord.

5. The next step is to cut through the layer of infundibuliform fascia which surrounds the sac and cord in common, change the

clamp so that it grasps the exposed sac over its anterior margin, then with the thumb and forefinger of the right hand and a piece of gauze the cord is separated from the sac until the sac occupies a position above the forefinger of the left hand and the cord below. The sac is then cautiously opened to determine whether it is empty or contains omentum or bowel. If empty the anterior layer is then cut across the clamps, having first been attached to the upper end of the sac. The lower end of the sac can then be dissected out if it does not communicate with the tunica vaginalis; if it does, it is dissected down until the testis is reached, a purse-string suture is placed around the distal portion and the remainder removed. The proximal end of the sac is dissected upward until it widens out into the peritoneal cavity. At this point the sac is transfixed in the center with a double No. 1 plain catgut ligature and then tied off, so that there is no longer any funicular process of peritoneum. The cord is then held up by means of a strip of tape and clamp and the first row of buried sutures inserted as follows: The cord is held upright and the first suture of medium size kangaroo tendon (not too large) is introduced by means of a curved Hagedorn needle through the upper portion of the internal oblique muscle, coming across the inguinal canal so that it just touches the lower border of the cord when the latter is held vertically to the plane of the abdomen. The suture is passed outward, first picking up the cremaster muscle, and then the shelving edge of Poupart's ligament, and is finally tied.

The second suture is placed in exactly the same way, one-half inch below. The cremaster muscle is included in the first two sutures, thus affording additional strength to the deep layer. The benefit of thus utilizing the cremaster was first pointed out by Halsted, of Baltimore, many years ago. We believe it to be of considerable advantage.

Four sutures are usually required in adults. The fourth is perhaps the most important suture of the whole operation and is inserted in a special way, as follows: The external oblique is reflected inward and the ilio-inguinal nerve, which up to the present time is held on the inner side by a retractor, is now

released and allowed to drop back into its normal place. The reflected portion of the external oblique about one-half an inch above where it meets the conjoined tendon is picked up with a sharp Hagedorn needle. The needle then crosses over the nerve and picks up the outer portion of the conjoined tendon, crosses over beneath the cord and enters the lower part of Poupart's ligament, close to its attachment to the pubic spine. The tighter this suture is drawn the more room there is for the underlying nerve, which can never be compressed. This is essential, as a great deal of neuralgic pain, which often follows hernia operations, is undoubtedly due to this nerve having been caught in the sutures. When this suture is tied the lower portion of the inguinal canal is completely closed up to the pubic bone. This stitch is not a part of Bassini's original technic, but we believe it has distinct advantages and greatly lessens the number of recurrences.

Another modification in the Bassini method, which we have used at the Hospital for Ruptured and Crippled the past twenty-five years, is inserting one suture above the cord, passing it through similar structures to those below, making a new internal ring exactly sufficient for the cord to pass through without undue constriction, and, on the other hand, of sufficient size not to favor a recurrence. The aponeurosis is then closed from above downward by means of a continuous suture of fine kangaroo tendon, leaving just sufficient space at the lower end for a new external ring, through which the cord emerges.

The operation for inguinal hernia in the female is precisely the same as the operation we have just described, except that the round ligament is preserved and not transplanted.

Femoral Hernia. The method employed in practically all cases of femoral hernia has been the simple, so-called purse-string operation, consisting of (1) a very thorough removal of all the overlying fat which, in many cases of femoral hernia, completely surrounds the sac and makes it somewhat difficult to find the latter; (2) a very thorough freeing of the sac, putting it down so that it is possible to place the ligature well beyond the neck, and (3) the closure of the femoral canal by means of a purse-string

suture of kangaroo tendon. Using a curved Hagedorn needle the suture is placed as follows: The needle is first passed through the inner portion of Poupart's ligament or the roof of the canal, then downward, taking firm hold of the pectineal fascia and muscle, then outward through the fascia lata overlying the femoral vein, and finally upward, emerging through the roof of the canal about one-quarter inch distant from the point of entrance. When this suture is tied the floor and the roof of the canal come into easy apposition and the femoral opening is completely obliterated.

Umbilical Hernia. The Mayo method of overlapping was adopted at the Hospital for Ruptured and Crippled soon after it was published in 1898, and our results, we believe, show it to be superior to all other methods. The main principles of the operation are:

1. Transverse elliptical incision, including the umbilicus and, in very obese people, a considerable amount of redundant skin and underlying fat. This incision is carried down to the aponeurotic layer. Instead of incising the sac over the distal or most protuberant portion the opening is made near the neck of the sac or rather just outside of the aponeurotic ring from which the sac emerges. The reason for this is that in most cases of large umbilical hernia the sac contains great masses of irreducible omentum which are apt to be adherent to the distal portion of the sac, while the sac in the neighborhood of the aponeurotic ring is quite free from adhesions. Hence, if the incision is made at this point, there is no danger of injuring the contents of the sac.

2. If adherent omentum is present within the sac it is freed from these adhesions and removed, care always being taken to tie it off in very small sections with catgut ligature. The fascial ring of the sac is then enlarged on either side by a transverse incision; the overlying fat is carefully dissected from the anterior surface of the aponeurotic layer for a distance of 2 or 3 inches. The wound is then closed by a series of interrupted mattress sutures of medium-sized kangaroo tendon or with chromicized catgut, placed in the following manner: A Hagedorn needle,

kangaroo tendon of medium-sized sutures, pierces the upper flap 1 to 2 inches from its margin, passing through the entire thickness of the aponeurosis and peritoneum and then transversely through the whole thickness of the lower flap about $\frac{1}{4}$ inch from its margin; on returning it is passed through the under surface of the upper flap, the same distance from the margin, and $1\frac{1}{4}$ inches distant from the point of entrance. A sufficient number of sutures are passed in this way, to completely close the opening. It is advisable to insert all the sutures before tying any. When these sutures are tied the upper flap will overlap the lower $1\frac{1}{2}$ to 2 inches. The edge of the upper flap is then fastened, sutured with a continuous suture to the anterior surface of the underlying lower flap. This makes a firm double barrier to guard against recurrence.

Undescended Testis.—The method of operation in cases of undescended testis consists in free incision of the external oblique, as in the Bassini method of operation. The sac in all cases of undescended testis is extremely thin and the dissection must be made with great care. After the sac has been cut across, just above the testis, it is freed well up beyond the internal ring and tied off as high as possible. The lower end of the sac is sutured over the testis making a complete tunica vaginalis. The next step is to remove all the fascial bands which surround the veins. When this has been done it is usually possible to bring the testicle into the scrotum. In the few cases in which it is not possible the majority of the veins may be resected, leaving a little more than the vas and the spermatic vessels. This step was advocated by Dr. Bevan many years ago and has proved of very great value. In a very small number of cases gangrene of the testis is reported to have occurred, but we have not seen it in our experience. It should never be used as a routine measure, but only in the rare cases described. The cord is never transplanted but allowed to drop back in the lower angle of the wound; the internal oblique is sutured to Poupart's ligament, exactly as in inguinal hernia in the female. We do not suture the testis in the scrotum, as advocated by many surgeons.

In the majority of our cases the testis has remained in the

lower or middle scrotum, but in a considerable number it has retracted to the region of the external ring. In a few cases in which the testicle was of normal size at the time of operation it continued to develop in the normal manner after operation, but in the cases in which it was more or less atrophied at the time of operation it failed to increase in size after operation. In only two cases was the testis removed at the time of operation. It was so atrophied that it was almost impossible to recognize any testicular elements. Whether or not the undescended testis is of functional value is a problem which has not yet been settled. There are a few cases on record of parents with double undescended testis, that apparently have been able to produce children.

There have been no deaths in this series of 441 cases and no hernia has thus far been known to follow the operation.

The results in this group of cases might be used as an argument in favor of not transplanting the cord in the ordinary inguinal hernia in the male. However, it is hardly fair to draw this inference, for the reason that in the great majority of these cases the hernia was rather a potential one than an actual hernia, being merely an open process of peritoneum, communicating with the abdominal cavity and tunica vaginalis.

Direct Hernia. Far back in the early days of radical operation it was recognized that it was much more difficult to effect a permanent cure in direct inguinal hernia than in the oblique type. Special modifications of technic have been devised to meet these difficulties. Wölfler, in 1892, introduced a somewhat complicated technic in which the rectus was turned out of its sheath anteriorly and sutured to Poupart's ligament. Bloodgood, in 1898, published a modification of Wölfler's method and later advised opening the rectus sheath from behind. For many years we have held to the belief that the transplantation of the rectus muscle is almost essential to a permanent cure in direct inguinal hernia, particularly those of large size, and in our opinion the method described by Dr. William A. Downes[1] is the best thus

[1] Annals of Surgery, 1911, liii, 568.

far proposed for utilizing the rectus muscle. Unlike Slajmer we believe transplantation of the cord not only the method of choice in oblique inguinal hernia but of even greater importance in cases operated upon for direct inguinal hernia.

The method of operating on direct hernia as advocated by Dr. Downes is briefly as follows: (1) indirect and direct removal of the sac, with division of epigastric vessels; (2) the internal oblique and transversalis are held up by a small blunt retractor placed at the internal ring, and these muscles are followed, down and in, until they join the transversalis fascia at the outer margin of the rectus. The sheath of the rectus formed by these structures at this point is opened and the muscle is exposed down to its pubic attachment. By means of three sutures of kangaroo tendon the outer margin of the rectus muscle is sutured to Poupart's ligaments. The sutures are placed from below upward, and about one-half to three-quarters of an inch apart. In some cases four sutures are necessary. After this row of sutures has been completed the retractor is withdrawn and the usual Bassini operation performed from above downward, the internal oblique muscle being sutured to Poupart's ligament. The sutures in this case are just superficial to and between the first row. The external oblique is then closed in the usual way. There are three distinct layers instead of two as in the operation for oblique hernia. The cord is always transplanted and the cremaster if not too thin is included in the sutures uniting the rectus with Poupart's ligament. Up to the time of his report Doctor Downes had performed the operation in 50 cases of direct hernia; 10 had been traced for more than one year, having no relapse.

Further observation has, however, shown a certain number of relapses in the cases of Dr. Downes, and at present he is inclined to believe that as high a proportion as 10 per cent. of relapses will be found even after this method if the cases are traced to final results. In our own series Dr. Downes's technic has been employed only in a limited number of cases. Our aim has been to bring over to Poupart's ligament the anterior portion of the rectus muscle and rely upon the special stitch which we have already

described for closing the lower portion of the canal, which includes the reflected portion of the external oblique. This avoids the extra layer of suture to Poupart's ligament in Downes's technic. In many cases Poupart's ligament is so poorly developed and easily torn that the insertion of two layers may weaken the structure upon which we most rely for our repair of the canal.

Within the last twelve months one of the writers (Hoguet) has discarded this method of operating on direct herniæ and is trying out a new one which differs in several essential points. The indirect sac which, although very small in some cases, practically always exists and is first separated from the cord and opened. The deep epigastric vessels are not divided, but by traction outward on the indirect sac, practically all the peritoneum of the direct sac can be pulled externally to the deep epigastric vessels. By this method of treatment the danger of opening into the bladder when the direct sac is opened is obviated. Instead of suturing the rectus down to Poupart's ligament the deep sutures are introduced in the manner described for the innermost suture in the Bassini operation—that is, that instead of grasping only the conjoined tendon this structure, together with the reflected portion of the aponeurosis of the external oblique, is included within the deep sutures, the cord, of course, being transplanted. Over this the cut edges of the aponeurosis are sutured, anterior to the cord. None of the cases operated on by this method have recurred up to the present.

In spite of the most careful technic the porportion of recurrences in direct hernia will always be considerably greater than in the oblique variety. One of the chief reasons for this lies in the fact that most cases of direct hernia occur in adult males with poorly developed abdominal walls, and especially poorly developed internal oblique muscles. If the final results of the patients who have been operated upon for direct hernia are carefully followed up for at least a period of two years after operation we believe that fully 10 to 15 per cent. will show a distinct recurrence.

Suture Material. There is one very important point of technic which has an equal bearing upon all methods of operation for the

radical cure of hernia, and that is the material used in the buried sutures. Upon this factor often depends the success or failure of the operation. At the Hospital for Ruptured and Crippled we have had an unusul opportunity for observing the end-results of all methods of operation, and as early as 1890 to 1895 we began to see the increasing number of cases in which the disadvantages of using the non-absorbable sutures became very apparent. Since that time in the annual review of Hernia for *Progressive Medicine*, Coley has repeatedly called attention to these disadvantages and strongly urged against the further employment of non-absorbable sutures and buried sutures. In the early days, or twenty-five years ago, there was some excuse for their use because of the difficulties attending perfect sterilization of absorbable sutures. However, since those days it has been possible to obtain entirely reliable sterilized kangaroo tendon or catgut and there has been no further legitimate reason for the use of non-absorbable sutures in hernia. The suture that lasts more than three weeks is a disadvantage rather than an advantage, inasmuch as if there be any tension at the end of this period the suture will cut through until the tension ceases to exist, when the tendon will remain either as a harmless foreign body or, as is the rule in a not inconsiderable number of cases, will give rise to chronic irritation ending in an open sinus which persists until the foreign body has been removed. That these objections are not merely theoretical has been proved by a long series of observations. One of the most noteworthy cases illustrating this point was observed at the Hospital for Ruptured and Crippled in 1890, in which a silkworm suture had been used in a Bassini operation for inguinal hernia in an adult male six months before, and the wound had healed by primary union. At the end of this time a sinus formed and a suture was removed and the wound healed. He remained well for about two years when another sinus appeared; another suture was removed, and the patient remained well until three years and eight months later when a third sinus formed at which time the last of the sutures was removed. In addition to the discomfort attending these various periods of sinus formation the long-

continued suppuration with the consequent scar tissue, served to produce a relapse of the hernia.

In spite of the fact that such results have been frequently published and are generally known, silkworm sutures are still used in operations for the radical cure of hernia by some of the most distinguished surgeons here and abroad. Only a year ago a patient was sent to me for a sinus in the right groin and another one in the left upper scrotum, with the history that about a year before he was operated upon for a hernia and varicocele at one of the most prominent English clinics. The patient was told that in five weeks he would be ready for military service. At the end of five weeks a sinus appeared and remained open for about six months, when he was told he would never be able to go into the army, so he came to America. The induration in the left scrotum with sinus formation so closely resembled tuberculosis that this diagnosis was made in one of the out-patient departments in New York. It was not difficult to make a diagnosis, that buried or non-absorbable sutures were responsible for his condition. The sutures were removed and the sinuses promptly healed, but not until the young man had been made more or less of an invalid for nearly a year and until he had lost all opportunity of entering the army. The matter is so important that we have felt justified in again referring to it at such length.

From December, 1890, to January, 1918, 6090 operations for the different varieties of hernia have been performed at the Hospital for Ruptured and Crippled. The great majority of these operations were performed by a small group of surgeons—Drs. Bull, Coley, Walker, Downes and Hoguet—a small number by the assistant surgeons or house surgeons under our direct supervision.

Varieties.	Cases.	Recurrences.	Per cent.
Inguinal hernia in males (oblique)	4420	25	0.57
females (children)	690	1	0.15
adults	369	13	3.5
Direct hernia	33		
in adults (female)	13	1	7.7
Femoral hernia in children	69		
adults	182	8	4.4

(Four of these recurrences were in cases in which the operation was done for recurrent hernia, the primary operation having been done by other surgeons. They should therefore not really be included.)

Varieties.	Cases.	Recurrences.	Per cent.
Umbilical hernia in children	58		
adults	104	3	2.8
Ventral hernia in children	24		
adults	81	12	14.8

(Most of these were large ventral herniæ in stout women, following old laparotomies.)

Varieties.	Cases.	Recurrences.	Per cent.
Epigastric hernia	18	1	5.5
Lumbar hernia	1		

In 334 cases the operation was for undescended or maldescended testis. In practically all cases, with 3 or 4 exceptions, there was a hernia, either actual or potential, that is, an open funicular sac communicating with the tunica vaginalis.

It is noteworthy that not a single relapse has been observed in these 334 cases of operation for undescended testis.

Methods of Operation. The typical Bassini operation, or the Bassini with slight modifications which have been described was performed in inguinal hernia.

Inguinal hernia.	Cases.	Recurrences.	Per cent.
Bassini	3725	14	0.38
Cord not transplanted	792	11	1.3
Direct inguinal hernia (Bassini)	24		

It should be stated that these cases of direct hernia all occurred in adult females and in children under the age of fourteen years.

Femoral hernia.	Cases.	Recurrences.	Per cent.
Transplanting rectus	8		
Femoral hernia in children	69		
adults	182	8	3.1

It should be noted that four of the recurrences were in operations for recurrence.

The purse-string suture with kangaroo tendon was used in nearly all the cases after a very high ligation of the sac and the removal of all the overlying fat.

Umbilical hernia.	Cases.	Recurrences.	Per cent.
Umbilical hernia, vertical overlapping . .	34	2	5.8
transverse or overlapping	77	1	1.8

A study of the time of the recurrences, *i. e.*, the interval between operation and the time that the recurrent hernia was noted, is of very great interest and importance. In 4453 cases of inguinal hernia in the male, 25 recurrences were observed, and of these 13 occurred within six months to one year after operation; three within one to two years. The other cases occurred at longer periods after operation: one, after three and one-half years, 2 after seven years, 2 after three years, 1 after four years, 1 after fourteen years and 1 after twenty years.

Mortality. The mortality has changed very little since the earlier statistics. From December, 1890, to January, 1900, a period of ten years, 2732 cases were operated upon, at the Hospital for Ruptured and Crippled, with six deaths, or 0.22 per cent. From January, 1901, to January, 1918, 3358 were operated upon with 6 deaths, or 0.18 per cent. The later deaths occurred, for the most part, in cases of large irreducible strangulated umbilical hernia.

In regard to the end-results of the first period we find 15 recurrences in 2029 cases of inguinal hernia in the male, or 0.73 per cent. in the cases operated upon by the Bassini method and 42.8 per cent. in the small group of cases operated upon by Czerny's method.

In the second period, from 1900 to 1918, covering 220 cases, there were only ten relapses, or 0.45 per cent.

CASES OF INGUINAL HERNIA OBSERVED AT THE HOSPITAL FOR RUPTURED AND CRIPPLED

	Under 1 yr.	1-4	5-9	10-14	15-19	20-29	30-39	40-49	50-49	60-
Male	4	790	1929	833	34	18	28	7	7	3
Female . . .	..	86	322	150	60	84	86	47	18	18

In this series so far as it has been possible to trace, 1667 cases have remained well from one to four years; 586 cases have remained well from five to nine years, 193 cases have remained well from ten to fourteen years, 46 cases have remained well from fifteen to nineteen years, and 14 cases have remained well from twenty to twenty-six years.

Of 216 cases of femoral hernia, 169 have occurred in adults and 47 in children under the age of fourteen years; 99 cases have been traced in which the patients have remained well from one to twenty-four years after the operation and in the entire series 14 recurrences are known to have taken place.

Of 166 cases of umbilical hernia, 116 occurred in adults and 48 in children; of the latter, 21 occurred in males and 27 in females. In 66 cases the patients are known to have been in good condition from one to eleven years after the operation and in 25 cases for more than three years; 9 recurrences have taken place and 5 deaths—among the deaths was 1 case, a female, aged forty-four years, in whom an extensive operation for carcinoma of the ovary was performed in addition to the hernia operation, and the patient died four days later.

Of 103 cases of ventral hernia, 86 occurred in adults and 17 in children. In this series 41 have remained well from one to fifteen years, the remainder not having been traced. There were 11 recurrences.

Of 15 cases of epigastric hernia, 12 have occurred in children under the age of fourteen years and the remainder in adults; 6 cases are known to have been well from one to seven years after the operation and in 2 cases a recurrence took place.

Direct Inguinal. There have been observed at the Hospital for Ruptured and Crippled 54 cases of direct hernia, including 4 doubles, making a total of 58 cases of direct hernia. Of these, 37 cases occurred in adults (21 in females and 16 in males) and the remainder in children under the age of fourteen years. As regards the sex in the latter, all occurred in males with one exception. These figures, however, do not represent the actual relative proportion occurring in the two sexes. It is only during the last year that adult males have been admitted to the Hospital for Ruptured and Crippled. Direct hernia in the female is extremely rare and the relative proportion is more accurately shown in our statistics elsewhere. The final results in this list of 58 cases is of interest. In only 1 case is a recurrence known to have taken place. This case was complicated with a separate interstitial sac coming out of the internal oblique external to the internal ring and not connected with the round ligament; a recurrence took place seven months after the operation. Of the cases that have been traced, 18 have remained well from one to eight years.

The final results in the cases of undescended testis will be given in detail in a separate paper. A brief summary of the cases observed at the Hospital for Ruptured and Crippled is as follows:

Of 314 cases of undescended testis only 10 occurred in adults over the age of fourteen years. So far as can be traced 123 cases have remained well from one to twenty-one years after the operation, 64 cases over three years and 14 cases over ten years. It is interesting to note the position of the testis in these latter 14 cases. In 1 case well twenty-one years the testis was atrophied; in another well thirteen years after, the testis was not felt; in another well fourteen years the testis was outside of the external ring and the size of a hickory-nut; in another well eleven years the testis was not felt; in a second well eleven years the testis had disappeared; in 1 case well twelve years the testis was normal in size and position; in another case well twelve years the testis was small and at the spine; in another case well twelve years the

testis was in the channel; in 1 case well eleven years the testis was atrophied and lying on the external oblique just above the external ring and so on.

This large group of cases (405), including those observed by the writers at the Memorial Hospital, should throw some light upon the important question of whether the trauma connected with bringing the testis into the scrotum by operation favors the development of malignant disease. So far as we have been able to determine, in no single case in our series has the patient afterward developed a sarcoma of the testis. One of the authors (Coley), however, has observed a case of sarcoma in an undescended testis shortly after an operation had been performed for bringing it into the scrotum. The patient was operated upon in another city and it is impossible to state positively that the disease had not been fully developed before the operation, although in all probability in this case the trauma connected with the operation was an exciting factor.

Strangulated Hernia. Of the 31 cases of strangulated hernia observed at the Hospital for Ruptured and Crippled it is interesting to note that the majority occurred in children under the age of two years. The youngest case was a child, aged thirteen days, with a loop of small intestine fourteen hours strangulated. A Bassini operation was performed and the patient was well when last traced, many years later; 7 of these cases were under one year of age and 10 under two years. It is especially worthy of note that the only death in this series occurred in a woman, aged fifty-one years, with a very large strangulated umbilical hernia. The only recurrence which took place was in a woman, aged thirty-five years, with a very large strangulated umbilical hernia which was complicated by a seven months' pregnancy. A hernia operation was performed and was followed by severe suppuration of the wound, which together with the unusual strain of childbirth coming on two months later favored a recurrence of the hernia, which took place eight months after the operation; 13 of these cases traced were found to be free from recurrence from one to twelve years after operation.

Contents of the Hernial Sac. The cecum alone and with the appendix was found in 27 cases; in 1 case there was a slight relapse one year after the operation; of the remainder, so far as were traced, 12 remained well from one to twenty-one years after the operation. The appendix was found in the hernial sac in 39 cases. In all but 3 of these, the age of the patient was under fourteen years. In 8 of the earlier cases the appendix was not removed, but in the remaining 31 cases the appendix was removed at the time of operation. The ovary and tube were found in 9 cases; the tube alone in 4 cases and the ovary alone in 4 cases. One case of special interest is that of a woman, aged thirty years, with a double strangulated hernia in which a strangulated Fallopian tube was found in the right femoral sac; the patient was well and free from recurrence when last traced, eight years after the operation.

In 17 cases the bladder was found in the sac; 10 of these cases occurred in children under the age of fourteen years and 7 in adults between the ages of twenty-five to sixty-five years. In every case with one exception the bladder was recognized before it had been opened. This particular case occurred in a woman, aged thirty-seven years, with a left femoral hernia; the patient made a good recovery without complications.

Seven cases of tuberculosis of the hernial sac were found, in all of which the diagnosis was confirmed by pathological examination. One of these cases died of tubercular peritonitis some time after; one was well four years later and the remaining cases were not traced.

The results at the Hospital for Ruptured and Crippled have been often criticized as not furnishing a true criterion of the value of the radical operation for hernia, because so large a proportion of the cases have been in children under the age of fourteen. It is assumed without debate that it is much easier to effect a cure of hernia in children than in adults. Although our statistics at the Hospital for Ruptured and Crippled prior to 1890, when the older methods of Czerny and Socin were employed, show practically the same proportion of recurrences

in children as in adults, yet we believe that children and young adults are more favorable subjects for operation than older people. In order to throw further light on this question, we have included 2499 cases of adults operated upon by Drs. Coley and Hoguet outside of the Hospital for Ruptured and Crippled, and in Dr. Coley's service at the Memorial Hospital by Dr. William A. Downes.

Of these 2499 cases, 1383 were operated upon by Coley and Downes, 595 were operated upon by Hoguet, and 521 were operated upon by Coley at other hospitals:

	Coley and Downes.	Hoguet.	Coley.	Total.
Inguinal in male, oblique	1057	465	333	1855
Inguinal in female, oblique	59	12	111	182
Inguinal in male, direct	153	75	24	252
Inguinal in female, direct	2	3	..	5
Femoral	65	15	21	101
Umbilical	23	11	31	65
Ventral	19	11	1	32
Epigastric	5	2	..	7
	1383	595	521	2499

Age as far as stated.	Cases.
Below 5 years	54
5 to 10 "	31
10 to 20 "	394
20 to 30 "	889
30 to 40 "	549
40 to 50 "	358
50 to 60 "	170
60 and over	54
Total	2499

Among the local sequelæ following radical operations for hernia are hydrocele and orchitis; among the general sequelæ: bronchitis, pneumonia, phlebitis and intra-abdominal swelling due to inflammation of the omental stump and embolism.

We believe that the local sequelæ are in direct proportion to the experience of the operator. If great care is exercised in dissecting the sac from the cord, with a minimum of trauma, the larger

vessels tied before cutting and the small bleeding-points controlled by ligature, hydrocele, orchitis or local swelling will very rarely be observed. We always support the testis by a little shelf or platform made of adhesive plaster placed across the upper portion of the thigh. Following operations for hernia we have observed 6 cases of pneumonia undoubtedly due to the anesthetic.

Excluding the recurrences which followed operations for strangulated and umbilical hernia we find in our series of 2499 cases 30, or a little over 1 per cent. of relapses. It has been impossible to trace the end-results in the adult cases as carefully as in the cases of children, and undoubtedly there have been a considerable number of recurrences in the former of which we have no knowledge. Allowing for these cases, however, the end-results in adults have been nearly as satisfactory as those in children.

The frequency with which thrombosis and embolism are the cause of death in abdominal operations, is brought out by E. H. Beckman[1] and L. B. Wilson,[2] both of the Mayo Clinic. Wilson states that during the period from 1899 to 1911 inclusive, 63,575 major operations were performed with 47 cases of fatal postoperative embolism, these fatalities representing 5 per cent. of the total number of deaths from all causes.

It is somewhat remarkable that thus far there have been no deaths from embolism in our series of 6090 operations performed at the Hospital for Ruptured and Crippled.

In 1383 cases operated upon at the Memorial Hospital by Drs. Coley and Downes there were 3 deaths. In the first case, a male, aged thirty-five years, operated upon by Dr. Coley, a large mass of omentum was replaced with some difficulty and probably considerable trauma. The patient died on the fifth day, with gradually increasing distention and signs of peritonitis. The second case operated upon by Dr. Downes died of infection and peritonitis. In a third case, operated upon by Dr. Coley at the Memorial Hospital—a very large irreducible umbilical hernia in a stout woman—death occurred. It was found almost impossible

[1] Annals of Surgery, May, 1913.
[2] Ibid., December, 1912.

to reduce the contents of the sac into the abdomen, and when reduced, respiration became difficult. The patient died two days later of heart failure; there was no evidence of sepsis. Another death occurred in a case operated upon at the Post-Graduate Hospital by Coley in 1895 in a strangulated femoral hernia with resection of the bowel.

Dr. Hoguet's series shows 6 deaths -2 males: 1 a strangulated indirect hernia, with general peritonitis, present at the time of operation and 1 a simple indirect acute, with atrophy of the liver; and 4 females: 1 a strangulated femoral, no resection, shock; 1 a strangulated femoral after gut resection; 1 a direct inguinal, acute nephritis, and 1 a ventral, with pulmonary embolism.

The Methods of Operation Best Calculated to Meet the Needs of the Army and Navy. The question of how to deal with the drafted or enlisted men with hernia has occupied no little attention of the Surgeon-General's office since the beginning of the war, and the problem has not yet been satisfactorily settled. The plan first adopted was to accept all men with hernia except the very large or irreducible cases, induct them into the service and then send them to the various cantonment hospitals, there to be operated upon by the surgeons in charge. This plan has not worked out with entire satisfaction for reasons that are apparent. We are beginning to study the question in the light of the experience gained by other nations which have been in the war longer than ourselves.

Canada began by adopting a plan very similar to our own, but we learn from Colonel Primrose and others that they were soon forced to abandon it because so many of the men broke down either from actual recurrence of the hernia or from real or imaginary troubles connected with the operation. These men became unfit for active duty. At present, in Canada, men with hernia are no longer accepted for active military duty even if operated upon successfully.

The British Army has attempted to solve the problem in a still different way. A special hernia department has been created and Lieutenant-Colonel Hull has been placed at the head. To

shorten the time of convalescence, he had devised a very simple method of radical cure which has been published in full in the *British Medical Journal*, October 27, 1917. It consists, in brief, of a short incision over the external ring; the aponeurosis is not cut; the sac is ligated as high up as possible and the external ring closed with two or three sutures. The operation is performed under cocain or local anesthesia and the patient is confined to the hospital for a brief period of about a week or ten days. The operation differs little from the old Czerny method, which we know from experience was followed by a large percentage of recurrences, 25 to 40 per cent. the first year. Lieutenant Hull believes that a large number of cases will be cured by this method and that those that do relapse can then be operated upon by Bassini's method.

We strongly disapprove of the adoption of such a plan in our own army. With the great shortage of men that exists in Britain it may be the best method for the British Army, although we doubt it.

Between the British plan of the very simple—and to our mind less efficient—method of operation and the Canadian method of rejecting all cases with hernia for military duty is there not some middle ground upon which we can formulate a plan which will more satisfactorily meet the exigencies of the case, at least for our own army? We believe there is and the plan we would propose is as follows:

Accept all enlisted men with hernia, with the following exceptions:

1. Large scrotal hernia (reducible or irreducible).
2. Direct hernia.

Send these men not to the cantonment hospitals, but to certain selected civil hospitals, so far as possible in the vicinity of their homes. Then have them operated upon by men who have had extensive experience in the operative treatment of hernia, allowing a considerable period for convalescence, at least three or four months, before sending them to the camps for active duty and six months before sending them to foreign service. It would

probably be longer than that before they would be sufficiently trained to go.

The statistics which we have just reported lead us to believe that it is possible to cure 95 to 97 per cent. of the cases of small reducible hernia in young adults from twenty-one to thirty-one years of age and fit them for the most severe strains of military life. More than ten years ago we adopted the rule on the New York Central Railroad to accept no employees with hernia until the hernia had been operated upon. Since that time a very large number of cases that were operated upon have been performing the arduous duties connected with railroad life, and thus far the number of recurrences observed has been extremely small, hardly worthy of mention. If these results can be obtained in the drafted men with hernia it would seem wise to utilize this very large number of splendid young men for active military duty instead of placing them in the deferred class.

The authors wish to express their thanks and appreciation to Dr. D. H. M. Gillespie for his very valuable aid in collecting the statistics for this paper.

OBSERVATIONS ON THE TREATMENT OF DIRECT INGUINAL HERNIA IN ADULTS

By LUCIUS W. HOTCHKISS, M.D.
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From a considerable experience with the surgery of direct inguinal hernia in adults, as well as from numerous observations made upon cases of recurrent hernia submitted to reoperation, I have been forced to the conclusion that the typical Bassini operation, while perhaps the most valuable single procedure that we have for the repair of the indirect inguinal herniæ, does not begin to fulfil the indications in the repair of these very troublesome cases of direct and potentially direct inguinal herniæ in middle-aged and elderly men.

I have been astonished, indeed, at the rather large proportion of these cases in hospital practice. They are sometimes small, sometimes of large size and many of them are incomplete and difficult to support with a truss.

They furnish a most interesting and ever-present problem to the surgeon and a not inconsiderable number of recurrences to the patient. It is a well-known fact that most recurrent herniæ seldom return to the original operator for repair, and unless one has had some experience in repairing the recurrences of some of his more skilful colleagues it is easy enough to fall into error as to the stability of his own results.

It may be well to admit, perhaps, that there is a small proportion of cases of direct inguinal hernia in men who are engaged in hard manual labor and whose tissues are relaxed and worn by toil, age and sometimes alcohol, in whom the repair is exceedingly

difficult and even impossible unless the habits of life are changed or the character of the work altered. The number of such cases, however, will grow steadily less as we learn to eliminate all possible causes of failure which are not directly chargeable to the inherent difficulties of the case itself. It seems to be very difficult to follow up for much more than one year most of our postoperative hernia results in city hospital practice. Cases which have been classed as cured at one hospital have a most distressing way of turning up at some other institution as recurrences; and to one like myself, who has had the privilege of serving at two hospitals in separate sections of the city, serving both ends of the line, as it were, there has come a rare opportunity of studying the results of others and at the same time furnishing me much food for thought as to who was taking care of my own failures. Thus many cherished illusions have vanished and a sharp stimulus has been furnished toward improvement in my own work. For a number of years, at Bellevue Hospital, I chose to operate upon such recurrent cases of hernia as came to my wards. These cases were not chosen because they were easy or because I liked to do them, but because I fancied they might furnish me some needed lesson. As a result of this work I found it necessary to modify my views as to the cause of postoperative recurrence of herniæ. In the first place it was found that infection played a much smaller role in the causation of recurrence than I had supposed.

Secondly, a very large number of the recurrent cases, indeed, were not recurrences at all in the strict sense of the word but rather a failure of the primary operation to wholly repair the original defect.

Allowing for the occasional case in which perhaps no radical cure could be expected, by reason of tissue defects, it seems a fair assumption, from my own experience, at least, that many of the operations which are done for the radical relief of direct inguinal hernia are often rather carelessly done, and that not infrequently the mistake is made of trying to make some one operation fit all the cases rather than to try to repair the breach by the method that seemed most appropriate to it.

Before passing through this somewhat chastening experience it had seemed to me that the harmless necessary hernia which, like the poor, we have always with us, could, as a rule, easily be cured by a routine operation which could soon be mastered and often handed over to the intern with perfect safety. This, I imagine, has been quite a common feeling with most of us; but the war, the workman's compensation act and the general tendency toward improved results and the general efficiency of surgical methods have all tended toward more careful work and a closer study of the common every-day problems of surgery.

In operating upon recurrent inguinal herniæ it soon became apparent that many inguinal herniæ have two more or less well-defined sacs—namely, an indirect, which presents in the usual situation, and a smaller direct bulge to the inner side of the deep epigastric vessels, which has to be carefully looked for. Under such conditions the indirect sac is readily seen and dealt with and the inguinal canal closed, *secundem artem;* but the potential or direct sac is often overlooked and later presents itself in the shape of a direct recurrent inguinal hernia, which had actually existed as a small potential hernia at the time of the original operation. This direct sac presents itself at the second operation for the so-called recurrence at the lower end of the repaired inguinal canal, and in most cases can be quite satisfactorily repaired.

The same rule obtains in many primary adult inguinal herniæ, and a systematic exposure of the whole neck of the hernial sac shows a well-defined direct hernia coëxtensive with an indirect hernia of which the sac may be large and descend into the scrotum. It is apparent then that if the one is repaired and the other ignored or overlooked there will be a return of the hernia sooner or later, and while the result may be classed as a recurrence, it is really a failure to fully repair the hernia at the first operation. In short, in overlooking the possible direct sac we unconsciously transgress against the first great law of hernial repair—namely, the tying off of the whole neck of the hernial sac as flush as possible with the parietal peritoneum.

The repair of direct inguinal hernia is sometimes easy and sometimes very difficult. Much depends upon the extent of the breach, the character of the tissues and the availability of some adjacent aponeurosis to supply the defect in the badly overstretched transversalis fascia.

In many cases the bulging of the weakened transversalis fascia to the inner side and behind the deep epigastric vessels, together with the almost complete disappearance of the so-called conjoined tendon, which is relied upon in the Bassini technic, makes it imperative for the surgeon to supply, if possible, some tissue which will stiffen up the posterior wall of the inguinal canal and supply the place of the weak overstretched fascia transversalis.

The method of repair which has been followed in these cases is as follows: Through a generous incision the inguinal canal is opened and the character and extent of the hernia definitely determined. An effort is made to define the whole extent of the hernial sac if there is a double sac, as is often the case; the indirect sac is separated from the cord, the deep epigastric vessels are divided between ligatures and pushed aside and the sacs opened. If it is found feasible to close the whole broad neck of the sac with a transfixion ligature this is applied. If, as is often the case, the neck of the sac is too broad and there is a sliding hernia of the bladder the neck of the sac has to be snugly closed by a purse-string suture. After dealing with the neck of the sac the deficiency of the weak transversalis fascia is supplemented by the utilization of the anterior sheath of the rectus muscle in the following manner: The thick aponeurosis of the anterior rectal sheath is thoroughly exposed by retraction and a long incision is made through it to the muscle beneath. Sometimes a triangular flap, with the base upward, is fashioned and turned back from the underlying muscle. This broad flap of strong aponeurosis is then carefully stitched by its outer edge to the whole length of Poupart's ligament from the spine of the pubes outward as far as necessary. The interrupted suture of chromicized catgut is applied, at rather close intervals, so as to snugly fortify the breach caused by the deficiency of the weakened transversalis fascia.

This it does very well and forms a firm strong wall for the posterior boundary of the inguinal canal. In cases in which there is great relaxation of the external oblique aponeurosis the principle of the overlap is further utilized and the layers are broadly imbricated. The cord is led outside of the fascia and rests in the subcutaneous fat.

Such a repair is effectual and lasting and has been used for a number of years, with increasing confidence.

I regret that it is impossible for me to furnish reliable statistics as to its efficiency, but as this is not a statistical paper, and as the principles utilized show nothing new or original but merely an attempt to utilize that which is tried and based on solid foundations, it is offered as a small contribution toward the effective treatment of a common and rather difficult surgical condition.

FECAL FISTULA FOLLOWING STRANGULATED HERNIA

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PRACTICALLY all cases of strangulated hernia unrelieved by operation invariably terminate fatally from peritonitis or shock. A small proportion, however, generally estimated at about 5 per cent., recover. In rare cases the destruction process will penetrate the sac and skin, and the patient will recover with a fecal fistula and artificial anus. Adhesions doubtless form between the strangulated loop of intestines and the wall of the sac. The hernial protrusion becomes red, tense and sensitive. Compression anemia of the intestine plus infection of the damaged loop results in gangrene and rupture, and the abscess finally ulcerates through the hernial sac and integument. Meanwhile the entire process has been walled off from the general peritoneum and self-cure is obtained by external perforation without peritonitis.

Five of these extremely rare cases have occurred in my service. Four were women of whom two were middle-aged and two were elderly, the other was a boy aged six years. Three were femoral and two were inguinal. The period preceding perforation was from ten days to two weeks. Two ruptured spontaneously, and three were opened for the resulting abscess. All drained fecal matter. Two healed naturally in four and five weeks respectively after evacuation of the abscess, two after freshening the margins of the opening, and one required abdominal section with detachment of the intestinal loop from its entrapped position in the femoral ring and suture of the opening. All recovered.

Case I.—About twenty years ago Dr. McClarny, of Crossville, Tenn., sent a large fleshy woman to me with a fecal fistula in the right groin. It had been discharging three or four months. There was a history of the femoral hernia for some years, for which a truss had been worn. The hernia had become strangulated and living across the mountain she was unable to obtain surgical or other attention. After great suffering the herniated mass became exquisitely tender and at the end of two weeks ruptured spontaneously. The contents of the bowels escaped at the site for some months when she was sent to the hospital for relief. About that time we were having a number of persisting biliary fistulæ after operation on the gall-bladder, as we were sewing the gall-bladder to the abdominal fascia. They were readily cured by making a circular incision around the margins of the fascial opening, allowing granulations to form between the freed margins of the gall-bladder that had been liberated from its attachment to the fascia. This idea was utilized in this case with prompt and satisfactory healing.

Case II.—A lad, aged six years, awakened crying with pain, and told his mother that the knot had come back in his side. Eighteen months before, the hernia had been irreducible for about a week, but there were no obstructive symptoms then or subsequently. There was swelling from the beginning and pain and vomiting. Normal defecation occurred on the first and second days and purgatives were given, and acted on the third and fifth days. Pain was considerable and the boy was confined to bed. Temperature appeared on the second day and continued. The swelling gradually increased. Topical applications were made, and on the seventh day it was poulticed. On the following day it appeared red and looked like an abscess, ready to be opened. On the ninth day Dr. W. T. Green, of Big Rock, Tenn., incised it. Considerable pus escaped and then several ounces of liquid feces ran out. The little boy was brought to St. Thomas Hospital on the seventeenth day (January 16, 1913) where the incision in the right inguinal region was enlarged and what ap-

peared to be a sphacelous knuckle of intestine about two inches in length was lifted out.

The fecal fistula remained for about four weeks and closed spontaneously. The boy has been quite well since.

Case III.—A woman, Mrs. Joe A., aged sixty-three years, entered the hospital December 7, 1916, with a discharging sinus and fecal fistula in the left groin of three months' duration. At that time she had noticed a slight femoral enlargement about the size of the end of the thumb. Within a few months she had two attacks of general abdominal pain with nausea, vomiting and constipation, followed by soreness and tenderness over the abdomen for several days. Three months ago she was seized with vomiting, cramping pains in lower abdomen, followed by a chill, fever and sweat. Vomiting persisted for forty-eight hours. No bowel action for five days; abdominal pain the while, with visible peristalsis. The femoral enlargement increased to the size of two fists. At the end of two weeks the tender mass ruptured and discharged a large quantity of pus which was later followed by fecal material which continued until two weeks ago, since which time the discharge was pus in moderate amount. Forty years ago she had a number of pulmonary hemorrhages, and has lived in Montana on that account with great improvement. There had been no hemorrhages for fifteen years.

The patient was kept in bed some two weeks and the sinus closed. She left the hospital and shortly the sinus reopened. Within two months she gained thirty pounds. The sinus alternately appearing to almost cease and then drain most profusely for a number of days. For several weeks peristalsis is noticeable and at times very active. Following a very severe attack of cramping, operation was advised for adhesion at the site of the former femoral fecal fistula. An incision in the left semilunar line disclosed the convex surface of a loop of small intestine firmly drawn into the femoral opening and densely adherent therein. It was separated with difficulty and the resulting rent at the site of the previous Richter's hernia with perforation, was closed with two layers of silk. Recovery was complete.

Case IV.—On the night of December 16, 1917, a woman, Mrs. C. E., aged fifty-eight years (No. A 6475), was admitted to the hospital with a very large abscess of the right groin of ten days' duration. The temperature was 102°. The skin covering the abscess was mortified and black over a considerable area. The house-surgeon was about to open it when he discovered that it was tympanitic. When I opened it later, the gas escaped and the greatly distended skin covering collapsed. Some foul-smelling feculent fluid was evacuated. The wound drained fecal matter copiously the next morning and continued to do so for about ten days and ceased completely. The wide-open wound soon became healthy and granulating, and was closed under local anesthesia on the fifteenth day.

Case V.—Mrs. V., aged forty-five years, mother of seven children, lived in a sparsely settled community on the Cumberland Plateau. She had a hernia which became strangulated on October 1, 1903. Dr. A. F. Richards, of Sparta, was called to see her October 13, and found her with pulse 140, temperature 103.5°, abdomen swollen to its fullest capacity, and the woman propped in a semirecumbent position, panting for breath. Her condition was extremely critical for several hours after the doctor's arrival, pending the use of stimulants and opiates. The hernial protrusion had sloughed and ulcerated through the right side, forming a fecal fistula through which gas and feces poured. She gradually improved until November 18, when the doctor found her with normal temperature and pulse, sitting up in bed, taking nourishment, but still having continuous fecal discharge from the fistula with an occasional normal bowel action. This continued until the following January, when I saw her, and opened the external fistulous tract, curetted the sinus and used stimulating applications, after which the fistula healed in about three months. She was seen some three years later by Dr. Richards, and was at that time entirely and completely well.

DISCUSSION ON THE PAPERS OF DRS. DOWNES, COLEY, HOTCHKISS AND HAGGARD

Dr. Charles L. Gibson, New York City:

I should like to say a word about direct inguinal hernia because it is only of recent years that I have learned how to handle it. I want to substantiate everything which Dr. Hotchkiss has stated. The direct sac must be dissected off of the bladder, and this is not done by nine-tenths of surgeons. The ridiculous thing is the descriptions in various text-books of direct inguinal hernia; most of them give no directions how to treat it or of the difficulty of treating this concealed sac, which is a serious reflection on our surgical knowledge.

Dr. Alexander Primrose, Toronto, Canada:

I may add another case to those already reoprted by Dr. Haggard. This one was a patient seen by me suffering with strangulated inguinal hernia. He refused operation. An abscess formed in the scrotum which opened and discharged pus; he developed a fecal fistula and recovered.

With regard to Dr. Downes's paper, I may report the case of a private in the Canadian Infantry who was injured in France in October, 1916, being buried under the earth after a shell explosion. Subsequently he complained of difficulty in breathing. The heart was found displaced to the right. There was a history that soon after the injury bloody fluid was drawn off the left chest. There was hyperresonance over the left chest and a very definite and characteristic "coin sound" could be elicited through the chest. X-rays showed the stomach in the left chest rising as high as the second rib. Enemata with an empty stomach showed the splenic flexure of the colon lying on the outer side of the stomach in the chest. He had no vomiting and little or no disturbance from this remarkable condition of affairs. Major Morgan, at Ramsgate, subsequently *x*-rayed this patient when I was present and I saw the screening. On lying down the bismuth lay high up in the chest as indicated. On standing the bismuth gravitated to the lower part of the stomach. The level of the diaphragm could be made out in its normal position. This man had little or no discomfort. He was a heavy beer-drinker, and when he had a chance could consume large quantities without apparent discomfort.

Dr. K. A. J. Mackenzie, Portland, Oregon:

I have noted for a long time that many surgeons disregard the importance of the cremaster muscles. Five or six years ago I adopted

the plan of stripping it from the internal to the external ring, picking it up and separating it from the cord, and then the cremaster is pushed to one side. When examined after this is done it is found to be a substantial structure. I adopted then the plan of suturing the cremaster muscle, grasping it on one side, beginning at the internal ring, then grasping the skin flap in the suture and suturing it to the edge of Poupart's ligament. I have always found that a very substantial bed for the cord. Not satisfied with that, however, when I treated the conjoined tendon at a little higher level of the internal ring, I sutured it higher above the shelving edge of Poupart's ligament. I am in charge of a very large railroad corporation and do many hernia operations, in excess of 1500, and recurrences are very few in number. In periods of three years employees are examined, being given three different examinations. There were records of two cases of bubonocele. I attribute this good result to the adoption of this method. I consider the next important thing is in dealing with the sac to prevent dimpling within the peritoneum. The point is made by Dr. Hotchkiss that in studying indirect hernias, frequently there is a pouching of the peritoneum or transversalis fascia where the direct hernia presents.

Dr. Alexis V. Moschcowitz, New York City:

Text-books and special publications upon the subject of hernia give the recurrences after operations for the radical cure of inguinal hernia at from 3 to 7 per cent. These statistics usually arise from large clinics. I believe, however, that if the statistics of the occasional operator were included the percentage of the recurrences would be much higher. From a careful study of the subject I have arrived at the conclusion that the causes of recurrence are threefold: first, a proper operation, improperly done; second, an improper operation, properly done; third and most frequently, an improper operation, improperly done. The causes of success are only one; namely, a proper operation properly done.

Dr. Willy Meyer, New York City:

In regard to the case reported by Dr. Downes, I think he showed good judgment in making no attempt to replace the stomach. It is a dangerous procedure at the best, and even more so when one does not know for how long a period the stomach has been in the chest cavity. This case is certainly unique. The *x*-rays taken in the inverted position of the patient is most interesting, and I think this method should be adopted more frequently.

Regarding Dr. Haggard's observation of five cases of strangulations,

I would say that I have seen two such in my practice. I believe that after the inflammation sets in they are best left alone, except for the opening of the abscess.

Dr. Randolph Winslow, Baltimore:

I want to call attention to one thing in connection with direct inguinal hernia. It is by no means uncommon, and there is great danger in operating upon it of injuring the bladder. I have myself experienced such a misfortune, something like a cyst appearing, then clear fluid, and then my finger was in the bladder. Fortunately, it is not usually a very serious injury, but is an unpleasant one to have occur. When you see at the inner side of a hernia a fatty or irregular mass, which apparently does not belong there, always think of the bladder. It takes very little manipulation to rupture it.

HEMORRHAGE FROM AN ANEURYSM OF THE INTERNAL CAROTID ARTERY FOLLOWING SEPTIC SORE-THROAT

By JOSEPH RANSOHOFF, M.D., F.A.C.S., F.R.C.S. (Eng.)
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Hemorrhage has always been regarded as one of the most serious complications of phlegmonous processes. This is particularly true of those situated in the neck. Whether it occurs in the course of an angina Ludovici, the postscarlatinal infection of the throat or a retropharyngeal septic lymphadenitis or peritonsillar abscess, the bleeding is very liable indeed to be quickly fatal.

It has long been known that these hemorrhages almost invariably are arterial in character, rather than venous, because intravenous pressure is insufficient to overcome the pressure from without and agglutination of the vein with life-saving thrombosis results. Exceptions, of course, occur and the carotid artery has been tied for hemorrhage, following a septic process of the throat, which autopsy showed to have been due to an erosion of the internal jugular vein. This was a case of malignant tumor in which a ligature was loosely thrown around the carotid as a prophylactic against impending hemorrhage. The ligature was subsequently tied. The patient died the following day of hemorrhage from the jugular vein. (Beck.[1])

In a case of the late Dr. Dandridge, occurring in the Cincinnati Hospital, of a shot wound of the upper part of the neck, which entered with an infection, the common carotid artery was tied for hemorrhage. The autopsy revealed a wound of the vertebral.

While hemorrhage from the internal carotid, as the result of ulceration of the artery, is alluded to by all classical writers upon the subject, the cases are fortunately far from common.

Newcomb,[2] ten years ago, was enabled to collect 51 cases following quinsy and allied conditions, from a widely distributed literature, extending over a period of fifty years. This is not a large number, and it is likely that not a few quickly fatal cases have not been reported because there was no time for surgical intervention. In view of the comparative paucity of these cases it is remarkable, I believe, that I have seen two of them within three months of each other. Both in young subjects, one with a quickly fatal result, the other fortunately saved by the pathological condition, which permitted a timely diagnosis.

Case I.—The fatal case was that of a lad, aged seventeen years, who had a peritonsillar septic inflammation of the throat which invaded the retropharyngeal lymphatic and caused an abscess. The temperature rose to nearly 105°, with corresponding rapidity of pulse rate. The abscess opened spontaneously, and later the opening was dilated with a forceps. The temperature quickly subsided and it and the pulse rate were normal a week after the inception of the trouble. Notwithstanding this favorable expression of the general condition the discharge from the opening in the pharynx was, as I understand, extremely fetid. On the evening of April 21, following an excellent day, hemorrhage suddenly came from the carotid artery and proved fatal in a very few minutes. It was only when this hemorrhage supervened that I was asked to see the case.

Fearing the possibility of such an hemorrhage the nurse had been instructed to compress the common carotid artery, but her effort is this direction proved of no avail. In this case there was no evidence of arterial erosion until the fatal hemorrhage occurred. In the majority of cases, fortunately, the bleeding recurs from time to time and an opportunity is thus given to permanently and successfully cut off its source by timely ligation.

Case II.—The second case was that of a girl, aged sixteen years, seen with Doctors Rachford, Dreyfoos and Iglauer. She

was admitted to the Jewish Hospital, January 20, 1918. For two weeks previous to admission she had suffered from a septic sore-throat. The temperature varied from 101.5° to 105°. The white count varied between 14,600 and 20,000, attended with 75 per cent. polymorphonuclear, 7 per cent. small lymphocytes, 12 per cent. large lymphocytes and 6 per cent. mononuclears. Besides the condition within the throat there was a great deal of swelling in the glands of the submaxillary triangle of the left side, which because of a matted condition indicated an extensive periadenitis. There was noticed at this time a very decided narrowing of the left palpebral fissure and of the left pupil, the very characteristic signs of pressure on the cervical sympathetic cord.

The abscess was opened eight days before admission and the temperature seems to have subsided somewhat, but it continued irregular between 100° and 104°, with the pulse rate varying from 112 to 130. Three days before admission to the hospital a very slight hemorrhage came from the drainage opening in the pharynx, but this subsided spontaneously. This recurred with great severity on the day of admission. The temperature continued high, the patient was put under gas-oxygen anesthesia and the infected glands in the neck were removed. When the throat was then examined it was found that quite severe hemorrhage, which had occurred during the morning, was due to an aneurysm of the internal carotid artery. The examining finger detected in the posterolateral wall of the pharynx a swelling as large as a peach, elastic, distinctly pulsating and easily recognizable as an aneurysm, from which recurrent hemorrhage had come. Compression of the common carotid caused the pulsation to disappear. Since, if for no other reaon, because of the inflamed condition in the neck, it would have been impossible to tie the internal carotid artery, it was determined to tie the common carotid. The operation was performed at the point of election, but before the artery was tied it was compressed for five or six minutes, the patient being permitted to come partly from under the influence of the anesthetic, to determine as far as this might allow, whether coma or paralysis would result from the tying.

Nothing of either nature appearing the artery was divided between two ligatures. Considerable dyspnea (due to encroachment of the hematoma over the larynx), which was present before the operation, seemed to grow worse after this, so that in the afternoon a tracheotomy under local anesthesia was done. From this time the patient made an uninterrupted recovery. Three months after the operation the patient was perfectly well. There was no return of pulse in the temple and the eye symptoms had entirely disappeared.

When hemorrhage comes from the ulceration of an artery from within the throat it usually follows soon after the abscess has opened spontaneously or been opened. The reason for this is that with the sudden release of pressure on the vessel wall from the opening of the abscess the weakened area of the artery gives way, with the continuance of the pressure within. The suspicion may therefore arise that damage was done to the artery by unskilful use of the knife, the operator ignoring the close proximity of the carotid to the pharyngeal wall. Indeed, the surgeon himself may feel some qualms as to his responsibility for the arterial hemorrhage. This is shown to be unwarranted by the statistics of Newcomb, according to which there were seven immediately fatal hemorrhages from ulceration of the internal carotid, in which the abscess had not been opened. There were also 15 cases of secondary hemorrhage, following the spontaneous opening of the abscess. In all of these the hemorrhage was recurrent. Seven of these cases recovered. In a number of these recoveries no operation was performed, so that it may be questioned whether the internal carotid was really invaded.

The diametrically opposite end-results in these 2 cases can easily be accounted for by the fact that in 1 case a false aneurysm was formed and that in the other the bleeding was so profuse from the monent the artery gave way that there was no time for such formation. The second case is interesting because aneurysm of the internal carotid, even of the false type, which is not intracranial, is very uncommon. The intracranial variety, as evidenced by pulsating exophthalmos, is not at all rare. Of 1000

ligations of the common carotid, 113 were for pulsating exophthalmos. The extracranial internal carotid aneurysm, on the other hand, is exceedingly rare. According to an article by Shipley and Linn,[3] all carotid aneurysms (and the literature has been gone over very carefully) the great rarity of extracranial internal carotid aneurysms is emphasized.

According to Babbio,[4] there were only 18 cases of aneurysm of the the internal carotid to be found in the literature. The common carotid was tied eleven times in these cases, with five deaths. According to Matas these aneurysms are very rare, and when they do occur they are often mistaken for other conditions, with fatal results. Of 11 cases collected by Werner only 6 were correctly diagnosed before treatment. The case reported, without question, belongs to the class of erosion aneurysms, described by Matas.

In the treatment of aneurysms of the extracranial internal carotid the cases must be extremely rare in which any other treatment than the tying of the common carotid artery would be applicable. I believe no case has been recorded in which aneurysmorrhaphy has been attempted. In such a case as the one reported the preliminary operation for exposing the aneurysm would, of necessity, be a very extensive one, necessitating the temporary resection of the inferior maxilla. There would even then be practically insufficient room for the treatment of the sac or the closure of the eroded artery. While it may be practical in some of these cases to tie the internal carotid rather than the common carotid it was not favorable in the case reported on account of the condition of the cervical glands. Furthermore, there would be no signal advantage in a case of this kind in tying the internal carotid, since a great danger of course would still be from cerebral anemia.

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RIGHT COLECTOMY: REPORT OF NINETEEN CASES

By G. W. W. BREWSTER, M.D.
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The object of this paper is to make a preliminary report of the results in a series of nineteen operations in which the right colon was excised. This operation was performed for the relief of symptoms which were attributed to blocking of feces in the cecum. I have no intention of discussing the general subject of stasis, or the question of its surgical treatment. I have a full realization of the confusion as to indications for operation and the difficulty of determining the actual results following operations for so-called intestinal stasis. I feel that this is a distinctly difficult subject to deal with, without being grouped with those surgical enthusiasts who have recklessly resected colons and unhesitatingly anastomosed the ilea to various segments of the sigmoid and rectum. While agreeing entirely with the opinion expressed so completely by Bevan before this Association a year ago and his condemnation of all operations for functional disturbances of large intestine, I have felt that there might be a condition of abnormal dilatation of the cecum resulting from partial obstruction in the colon beyond in which resection might be justified. This series of cases represents a group taken from the Massachusetts General Hospital, as a special assignment, and those referred to me by private physicians. Each case had been under careful study and observation by competent men, and in each case there was thought to be a condition, unrelieved by previous treatment, which justified exploration. The question of excision was to depend upon operative findings, and was only undertaken when the location, mobility, size of the cecum and existence of

bands and adhesions seemed to point to a possible condition of partial obstruction. The operation was undertaken with a clear understanding of the cloudiness of the subject of stasis, with the hope that not only might the patients be benefited but that the writer might obtain some personal impressions as to the true amount of benefit to be expected in this type of case, and have some standard as to the type of case which would not be benefited. Uncertain as this subject is, the writer has felt that there are some cases in which right colectomy might be the only method of relief.

The group of cases representing those operated on at the Massachusetts General Hospital was referred to me for operation for relief of more or less severe and unrelieved constipation with evidence of *x*-ray and clinical symptoms that the region of the cecum was the location of the cause. Most of these cases have come from the nerve department because of the work being done there in connection with the relation between epilepsy and chronic intestinal stasis. In all a large, movable cecum was found with constricting bands in the ascending colon beyond the ileocecal valve.

The other cases operated on were referred by physicians who had become convinced that the cause of partial invalidism was due to abnormal delay in the cecum and that exploration with possible excision was justified.

Operation therefore was undertaken for definite symptoms of intestinal obstruction, as demonstrated by marked constipation, palpable masses in the right iliac fossa, distention, and roentgen-ray demonstration of stasis in the ileum and cecum. The right colon was excised in those cases in which mechanical obstruction was found. Pathological study of many of the specimens has been made and nothing abnormal demonstrated. Many of these cases had had a previous appendectomy for chronic right-sided symptoms without relief.

In these 19 cases I have discovered nothing new in the method of technic and have followed out the suggestions of other operators. The mobilization of the colon as described by Mayo simplifies the procedure, and lateral anastomosis with clamps

reduces the chances of sepsis to a minimum. In all of these cases the same method has been followed, and the only complication in the convalescence has been the infection of two of the abdominal incisions, with suppuration in the abdominal wall. All have passed through an unusually favorable convalescence; there has been no case with gas distention or difficulty from postoperative ileus. In fact, it has been noted by the house staff that these cases have had less trouble with gas than many of the other less extensive abdominal operations. I think the method of suture is not of great importance and may be left to the individual preference of the operator.

The absence of postoperative distention has led me to feel that attaching the site of suture to the abdominal wall is unnecessary.

I believe the immediate result in this operation is influenced largely by two facts: (1) there is almost no handling of the intestines or abdominal contents, except that of the segment which is subsequently entirely removed, and (2) the avoidance of infection.

Decision to operate on these cases rests both upon the clinical observation of a group of symptoms which in my own operative experience I have seen relieved by such an operation as is here described, and upon the demonstration of a cecum abnormally mobile, with a varying number of obstructing adhesions distal to the dilated portion. Such apparent abnormalities have been demonstrated in all of the reported cases, and resection has not been undertaken unless such factors were demonstrated. The statement of results is based upon examinations and reports of the patients. The fact that preoperative symptoms have been relieved is accepted as proof of the benefit of the operation.

One case was that of a young married women, three months pregnant, who, ever since an ileosigmoidostomy by another surgeon two years previous, had had intermittent attacks of vomiting, nausea and abdominal distress, all much aggravated during the pregnant period. Her condition was reduced to such an extent that some interference was deemed absolutely necessary. I felt that either the short circuit should be undone or that some operation should be undertaken to relieve the backing up in

the cecum. I found a large, dilated cecum, with a long mesentery lying free in the right side and forming a green-colored pouch filled with pasty fecal matter. The ileum was cut off the sigmoid and the opening closed; a lateral anastomosis was then done between the ileum and transverse colon near the beginning of the omentum and the right colon excised. This patient made an uninterrupted recovery from the operation, with very marked improvement in the general condition. Subsequent history in the following two months showed a gain of fifteen pounds, with no return of the symptoms which antedated the operation. All of the original symptoms unrelieved or made worse by the ileosigmoidostomy were now relieved, as was also the persistent vomiting. The pregnancy was normal and uninterrupted in its course.

I will speak of one other case, a child aged four years, who had been operated on in another clinic for acute appendicitis a year previously, and a condition of colitis found which led to the making of an appendicostomy for irrigation of the colon. After irrigation for eight months, with some improvement in the general condition, there developed symptoms of obstruction and general nervous attacks which were attributed by the attending physician to backing up in the region of the cecum. The patient was referred to me by a very careful internist, who was convinced that the child was suffering from an abnormal condition in the cecum. On opening the abdomen the cecum was found adherent to the abdominal wall, much dilated at the lower end, with an unusual number of adhesive bands along the ascending colon and especially at the hepatic flexure. I excised the cecum and anastomosed the ileum to the transverse colon. This child, now three months after operation, shows a most striking improvement in general condition. He has been entirely relieved of his previous symptoms and has gained steadily in weight, eats normally for a boy of his age and has daily normal movements of the bowels.

It may be said that this case does not prove that operation was indicated or that the operation was necessary so far as any pathological condition was found or demonstrated; but to the

physician who had the case under observation, and to myself, it is shown that the operation has been the cause of the child's improvement and that the condition existing before operation was the cause of the symptoms of chronic invalidism.

In summing up the result of the operations in the 19 cases I am convinced that cases of right-sided obstruction in which stasis is located in the cecum or ileocecal region the result of mechanical or apparent mechanical causes may be successfully cured by resection of the right colon. I do not feel that it is yet possible to collect absolute data as to what signs justify operation and in which cases it is indicated. The immediate result of the operation shows it to be one which can be done without undue risk: 20 cases reported by Mayo, 12 by Johnson and this series of 19 without a death.

Twelve of these cases were epileptics, in which there were symptoms of obstruction manifested by extreme constipation or recurring attacks of right-sided pain, with distention and masses in the cecum. Operation was undertaken primarily for relief of a possible mechanical partial obstruction, causing dilatation of the cecum and backing up of the intestinal contents.

Although a majority of these cases have been largely relieved of the constipation and have shown a marked improvement in their general condition there has been slight if any change in the epileptic attacks. It is only fair to state, however, that the physician who has these cases under his personal care and observation feels that it is impossible to make more than the preliminary statement, that the operation has been of some benefit and that there are possibilities of more definite results in the future. At the present time no case has shown any unfavorable condition as a result of the operation. In other words, if the operation has been of no great permanent benefit it has not been followed as yet by a condition worse than that which preceded it. So far as epilepsy is concerned, unless symptoms of obstruction in the right colon were found to be of a mechanical cause, I should not feel that operation was indicated.

In 5 cases in which a large, dilated cecum was found, with adhesive bands producing apparent constriction of the ascending colon and hepatic flexure or angulations with adhesions, there has been entire relief. Previous to operation 3 of these 5 cases had recurring attacks of right-sided pain, with constipation, and 2 of them had a persistent and incurable constipation. In the 2 remaining cases operation was for dilatation of the cecum from backing up of the intestinal contents following an ileosigmoidostomy. The result was entirely satisfactory in 1 case and partly so in the other.

The study of these 7 cases shows that in 6 there is entire relief of former symptoms, in 1 only partial relief.

The relief of symptoms has been so marked that I am inclined to believe that the condition of the cecum was abnormal and that there was some abnormal obstruction of the ascending colon or hepatic flexure and that the operation was indicated.

The appearance of the cecum was thought, by the operator and by those present, to be abnormal, but it has been impossible for the pathologist in his examination of the specimens to show anything abnormal. Even the decision as to whether there were abnormal adhesions or bands is open to question, for I have certainly found similar conditions in patients without symptoms.

I confess that the immediate results were so satisfactory that signs may have been too quickly interpreted as justifying excision in some of the 19 cases.

Conclusions. 1. Although right colectomy has been reported by others without mortality and my personal experience has added a series of 19 cases with favorable results, it is an operation which in a large series of cases may show a definite mortality of considerable percentage.

2. In spite of the very satisfactory outcome in certain of these cases the writer feels that the operation is too serious to be undertaken except for very definite conditions of incurable partial obstruction.

3. The indications for excision are dilatation of the cecum, extreme mobility and the presence of adhesions, in patients

unrelieved by any palliative treatment, and whose symptoms lead to chronic invalidism.

Case I.—R. P., aged eleven years, November 6, 1915. Referred by Dr. Ward of Lynn.

Operation performed for dilated cecum and stasis associated with epilepsy. Large dilated cecum, chronic appendix and adhesions in the hepatic flexure. The terminal ileum, cecum and two inches of the transverse colon excised. Lateral anastomosis done between the ileum and the transverse colon.

Good recovery from the operation. Return of the epileptic seizures after two months.

Case II.—Mrs. A. C., aged forty years. February 6, 1917. Dr. J. M. Jackson of Boston.

Appendix removed in 1905. Operation in 1915 for fibroids. Since that time has had symptoms of stasis, dilatation of the cecum with pain in right side. Patient has become chronic invalided.

Roentgen-rays before operation showed movable, low cecum and some ileal stasis.

Operation. Large movable cecum found; adhesions along the hepatic flexure; incompetent ileocecal valve. Removal of right colon; anastomosis of the ileum to transverse colon. This patient made a perfectly satisfactory recovery.

Report, May, 1918. Entirely relieved of symptoms existing before operation.

Case III.—F. E. F., aged twenty-two years. July 20, 1917. Referred by Dr. Drowne, Boston.

Has had epileptic seizures since childhood. Has improved under Dr. Drowne's care.

Roentgen-ray report is hepatic flexure at an abnormally sharp angle; sigmoid large and high; definite stasis at hepatic and splenic flexures, suggesting traps in these two places.

Operation for stasis. Right colectomy.

This patient made a very satisfactory recovery from the operation and the general condition was markedly improved. There has been some diminution in the severity of the epileptic seizures.

Patient and family convinced that operation has been followed by marked improvement.

Case IV.—Mrs. J. B. A., September 25, 1917. Referred by Dr. Dewis, Boston.

Was referred to me for operation on account of persistent vomiting and nausea following operation for ileosigmoidostomy two years ago. A large movable mass felt in right iliac region. Patient in poor condition.

Operation. A large dilated cecum, freely movable, partly filled with feces, found. Anastomosis of the ileum to the sigmoid was excised; opening in the sigmoid closed. Right colon excised. Ileum anastomosed to transverse colon.

This patient made a perfectly satisfactory recovery and was entirely relieved of symptoms of obstruction. Gained fifteen pounds in three months. Went through normal labor seven months after operation.

Case V.—Mrs. J. C. B., aged fifty-two years. September 25, 1917. Referred by Dr. Swaim.

Had an ileosigmoidostomy five years previously for stasis and symptoms of absorption. On account of the return of the symptoms, which seemed to be due to stasis, she was referred to me for operation. A dilated cecum could be palpated on the right side.

Operation. A large dilated cecum, partly filled with fecal matter, was found; also a large cystic dilatation of the blind end of the ileum, which was anastomosed to the sigmoid by a lateral anastomosis. These two sacs were filled with fecal matter. The rest of the colon seemed to be in normal condition. Anastomosis was excised, opening in the sigmoid was closed. Right colon was excised and a lateral anastomosis was done between the ileum and middle of the transverse colon.

This patient has only been in part relieved by the operation. Still has symptoms which are attributed to stasis, although marked improvement in the ease with which the bowels are moved. On the whole the patient is somewhat improved by this operation.

Case VI.—Mrs. B. S. August 15, 1917. Referred by Dr. Hewes, Boston.

Referred to me for chronic constipation and symptoms attributed to partial obstruction.

Operation. A dilated, movable cecum found, with adhesions along the hepatic flexure. The cecum was excised and a lateral anastomosis done between the ileum and transverse colon.

Report, May, 1918. This patient made a most complete recovery and is entirely relieved of all former symptoms.

Case VII.—Miss L. P., aged eighteen years. October 26, 1917. Referred by Dr. Browne, Boston.

Sent to me for removal of colon on account of stasis and epilepsy.

Operation. Right colectomy done, with lateral anastomosis between ileum and transverse colon.

No improvement in this patient's condition since operation.

Case VIII.—E. W., boy, aged three and a half years. February 14, 1918. Referred by Dr. Hamilton.

Has had appendicostomy opening for a year. Referred to me now by Dr. Hamilton for removal of part of the colon for stasis.

Operation. Many adhesions found about old operative wound; dilatation of the cecum. Two inches of the terminal ileum and right colon excised. Lateral anastomosis done between the ileum and transverse colon.

This patient made an uninterrupted recovery, with entire relief of preoperative symptoms.

Report in May, 1918, from mother that child is now perfectly normal.

Case IX.—D. S. G., aged twenty-five years. March, 1918. Referred by Dr. Sturgis, Lynn.

Referred to me for operation on account of epilepsy associated with symptoms.

Operation. A right colectomy was done, with anastomosis of the ileum to the middle of the transverse colon.

This patient made an uninterrupted operative recovery. Reports that there is enough improvement in general condition to resume work. No attacks as yet, May, 1918.

Case X.—M. G., aged eight years. November 7, 1917. Referred by Dr. Browne.

Epileptic since birth. Attacks associated with intestinal stasis.

Roentgen rays show dilatation of the cecum and adhesions or some cause of stoppage in the ascending colon.

Operation. Cecum enlarged and with a long mesentery, cecum freely movable and easily transposed to left side; appendix somewhat thickened; ascending colon at hepatic flexure tied down by many adhesions; first part of transverse colon formed a U and held by adhesions. Cecum and ascending colon mobilized. Resection of right colon and lateral anastomosis between the ileum and the transverse colon.

Specimens showed dilatation of cecum and mechanical obstruction from adhesions.

Good recovery from operation

Report, May, 1918. Improvement in general condition, but recurrence of epileptic seizures.

CASE XI.—Hospital No. 218244. Mrs. B. L. K., aged thirty years. October 25, 1917.

Extreme constipation for years. Has always been thin and poorly nourished. Occasional attacks of nausea and vomiting. General abdominal pain. Dizzy spells and many general nervous symptoms.

Lumps can be felt along course of the colon.

Operation. Large freely movable cecum. Many bands and adhesions along ascending colon and hepatic flexure. Resection of right colon.

Excellent recovery.

Report, May, 1918. Constipation entirely relieved.

CASE XII. Hospital No. 216895. Mrs. S. S. H., aged thrity-five years. August 21, 1917.

Epilepsy; intestinal stasis; dilatation of the colon. Convulsions for twenty years. Always very constipated.

Roentgen rays show dilated cecum and ascending colon; high right-angle hepatic flexure.

Operation. Ileum adherent to brim of pelvis; many adhesions along ascending colon. Resection of right colon.

Excellent recovery and convalescence.

Report, May, 1918. Constipation entirely cured. Great improvement in general condition. Still has epileptic attacks.

Case XIII.—Hospital No. 216907. Mr. K. S. S., aged twenty-three years. August, 1917.

Epileptic attacks for five years. Attacks associated with indigestion and constipation. Has been taking enema at night and morning for past three months to prevent attacks, if enema is omitted attacks recur.

Roentgen rays show unusually movable cecum; slight ileal stasis. Colon low but otherwise negative.

Operation. Freely movable cecum; bands and adhesions along ascending colon; numerous enlarged mesenteric glands. Resection of right colon.

Excellent recovery.

Report, May, 1918. Constipation entirely relieved. General condition markedly improved. Attacks persist.

Case XIV.—Hospital No. 216225. Mr. J. P. F., aged twenty-one years. July 19, 1917.

Intestinal stasis. Epilepsy.

Roentgen rays show low ascending colon. General ptosis of viscera.

Operation. Large mobile cecum; chronic appendix; many enlarged glands; bands and adhesions at hepatic flexure. Resection of right colon.

Excellent operative recovery.

Report, May, 1918. Attacks have recurred; not much change although no worse.

Case XV.—Hospital No. 216006. Miss H. A. M., aged twelve years. July 12, 1917.

Intestinal stasis. Epilepsy. Attacks of pain in R. L. Q.

Roentgen rays show large mobile cecum.

Operation. Mobile cecum; long mesentery; chronic appendix; vascular adhesions over cecum; enlarged glands. Resection of right colon.

Normal convalescence.

Report, May, 1918. Still has attacks. Constipation markedly relieved.

Case XVI.—Hospital No. 215871. Miss A. T. July 2, 1917.

Epilepsy. Intestinal stasis. History of constipation.

Roentgen rays show mobile cecum, colon low, otherwise normal.

Operation. Large distended cecum with long mesentery; chronic appendix with many adhesions about hepatic flexure. Resection of right colon.

Good recovery.

This patient has been lost track of.

Case XVII.—Hospital No. 215481. Miss L. H. June 12, 1917.

Severe constipation for twenty years. Recurring attacks of pain in upper abdomen. Poorly developed and nourished woman.

Roentgen rays show general ptosis of all viscera; mobile cecum.

Operation. Cecum dilated and movable; chronic appendix; adhesions of ascending colon.

Excellent recovery from operation.

Report, May, 1918. Has made marked improvement and now feels cured.

Case XVIII.—Hospital No. 215062. T. M., aged twenty years. May 23, 1917.

Epilepsy. Constipation and errors of diet bring on attacks.

Roentgen rays show dilated terminal ileum; mobile cecum; ascending colon. Resection of right colon, with lateral anastomosis of the ileum to transverse colon.

His convalescence was normal.

Report, May, 1918. General condition improved. Attacks milder, but still continue.

Case XIX.—Hospital No. 213196. Miss M. C., aged twenty-two years. February, 1917.

Convulsive seizures for a year. History of marked constipation; constant dull pain in R. L. Q.; worse after seizures.

Roentgen rays show intestinal stasis.

Operation. Chronic appendix; movable cecum; ascending colon covered with adhesions. Resection of right colon, with lateral anastomosis of ileum to transverse colon.

Marked improvement in general condition. Convulsions still continue, attacks less frequent. Constipation entirely relieved.

THE ABDOMINAL INCISION: WHEN NOT TO USE STITCHES

By ARCHIBALD MacLAREN, M.D.
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Everyone doing abdominal surgery frequently meets with cases so desperately sick that he realizes at once that he will be most fortunate if in any way he can possibly save the patient's life. Under such circumstances the occurrence of operative hernia is of no importance.

In the treatment of the ordinary every-day abdominal incision the kind and method of suture to be used is of the greatest importance. But there are many cases when this point is of very secondary consideration (Fig. 1).

The text-books on surgery of today do not draw any distinction between these two classes of cases and the surgeon wastes precious time and really interferes with the recovery of his patient by the same elaborate wound toilet in the bad case that he would use in his simple cases. Then, again, intra-abdominal distention is not given proper consideration by the surgeon. When it is necessary to open any such distended abdomen, where, for instance, the distention is due to intestinal dilatation, we must follow a very different plan of closure than we do in the case when the cause of distention can be removed. In any case when considerable abdominal distention follows a laparotomy, any form of suture under tension will cut through the tissues of the abdominal wall and predispose the patient to complete rupture if he vomits or coughs or to incomplete rupture, as seen in the ordinary postoperative herniæ. It has been assumed that an abdominal incision must be

sutured in layers to prevent the worst forms of operative hernia (C. G. Child, Jr.), or, if it were not sutured in layers, that it must at least have the old through-and-through suture of forty years ago.

Our experience of the past four years has proved to us that it is not necessary to suture these badly distended cases at all and that they do not develop bad operative herniæ even when no sutures are used to close them. We have prepared some slides from photographs which show that wounds which have been simply strapped with adhesive bands are good, strong abdominal wounds, with no marked evidence of hernial protrusions. Most of the cases in which we have used no sutures have been of the septic peritonitis type. Acute septic peritonitis follows some perforative intraperitoneal lesion. Perforation of the appendix is the most common cause. Then, according to our experience, would follow perforation of the duodenum, stomach, gall-bladder, ileum in typhoid, occasionally from the leaking of a pus tube; changing a local to a general peritonitis.

If a general peritonitis starts from any cause, the only chance of escape for the patient is drainage with closure of the perforation or removal of the cause where the patient's condition is such as to render removal justifiable.

Septic peritonitis is of many degrees of virulence, depending upon the character of the infectious organisms, and also upon the location of the perforation. All observers have agreed that the danger to life in these cases increases with each hour after the time of the perforation. Until operation can be performed all agree that these cases should be operated upon up to forty-eight hours after perforation. After that time many operators believe that the chance of recovery is so small that it is best not to operate but allow Nature to take its own course, hoping that the inflammation will localize and form an abscess which can be later safely opened and drained.

All surgeons today agree that these cases should be so treated as to minimize intestinal peristalsis, should not be given cathartics; should have cold applications to the abdomen; for excessive

vomiting should have gastric lavage. In our experience we almost never see a case of perforative peritonitis, thirty-six or more hours old, that has not had a dose of some cathartic, seldom prescribed by a medical man, but usually by some kindly intentioned neighbor. We frequently see cases for the first time on the third or fourth day, cases that show no tendency to abate or to localize, but that were rapidly growing worse. We have so many times seen death as the result of waiting under these circumstances that we now accept the risk of spoiling our statistics and open the abdomen even on the fourth and fifth day, so as to take the "lid off" and get drains into the abdominal cavity if, in our judgment, there is even a 5 per cent. chance of recovery.

These cases are desperately sick, possibly we have taken away the faint chance of a localization, but we do not think we have. On the contrary, we believe that we have saved some lives that without this procedure would have been lost. These acute peritoneal abdomens can be opened often with local anesthesia. Our rule would be open widely enough to find the cause of the perforation, close the perforation of the stomach or intestine, remove the gall-stones and occasionally the gangrenous appendix; put in plenty of split-rubber tube or cigarette-rubber tubing drains and close the abdomen with adhesive bands. The mistake which we have made a great many times, was in putting in sutures in the abdominal wall after treating one of these cases. They are almost sure to form a hernia, so do not waste time and really interfere with the drainage by putting in useless stitches.

As Ochsner says, "Try and cultivate as large a hernia as possible." Many authors advise, even in these bad acute cases, certain methods of opening the abdomen, such as the McBurney incision and certain methods of suturing, because by so doing you lessen the chances of hernia. In the cases of which I am speaking the question is not hernia but life. After these cases recover, as some of them do, the surprising thing is that they do not always develop a bad hernia. Some of them show almost no hernia at all. The abdominal wound is, it seems to us, every bit as good as one which has been carefully sutured. Recently we have adopted

the following method of wound suture in cases where there is more than ordinary tension or where we have reason to expect either excessive vomiting or coughing.

First, we put in interrupted catgut sutures, taking all the tissues from the external oblique down through the peritoneum, taking a wide bite of all the tissues. The return on the other side

FIG. 1.—Method of strapping abdominal wound in case. No stitches are used in closure.

taking the peritoneum, transversalis fascia muscles and external oblique fascia, completes the figure-of-eight by picking up a wide bite of the external oblique fascia on the other side. This stitch is made with a double No. 1 or No. 2 chromic catgut, and is interrupted in character, at least three such stitches to the inch. On top of these catgut figures-of-eight are now placed some silkworm figure-of-eight stitches, closing the skin.

Recently in spite of this latest method of suture we have had a wound vomited open on the eighth day after operation and found the intestines protruding between the loosened figure-of-eight silkworm-gut stitches, which were still in place.

Some five or six years ago while taking the history of an abdominal patient, I was told that two years before, after a

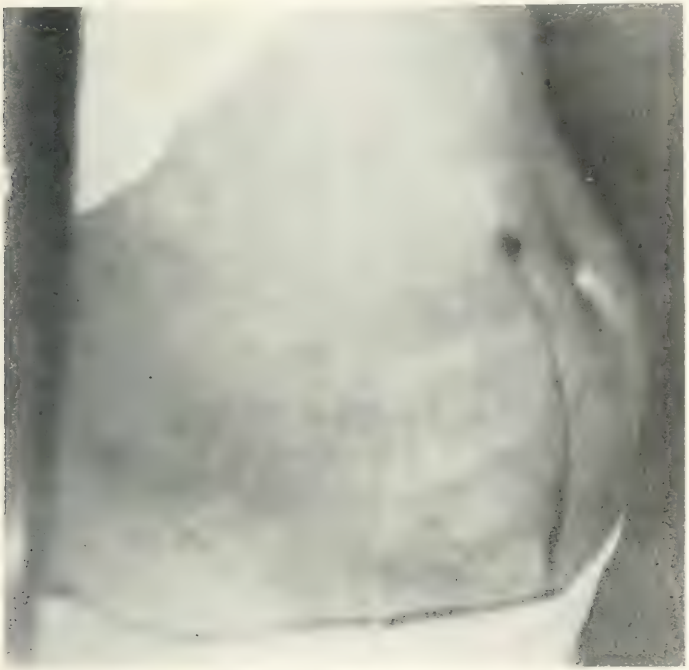

FIG. 2.—Miss R., case of Dr. Bomberger, Mapleton, Minnesota. Intestinal obstruction and fecal vomiting for thirty-six hours. Large gall-stone in terminal ileum; arterial embolus in popliteal artery with gangrene of leg to knee. Photograph taken two months after laparotomy and closure without sutures.

previous laparotomy, the patient had vomited himself open on the seventh day while the stitches were still in place; that the surgeon in charge had simply washed off the intestine, had pushed it back and then strapped the wound, putting in no new stitches.

The man's abdominal wound was so good that I cross-examined him closely until I was sure that I had the real facts: Since that

FIG. 3.—Case of girl. Acute septic peritonitis. No stitches in abdominal incision. Three months.

time I have been emboldened to do away with any kind of sutures, in a few cases, when I found great tension or when time was of importance.

The first case treated in this manner was operated upon October 21, 1913. She was forty-two years of age, five feet tall,

FIG. 4.—Wound coughed open. Strapped and no stitches put in one year before photograph was taken.

weighed 180 pounds, her abdomen was rigid, tense and much distended. She had been sick for four days when I first saw her.

with a temperature of 103°; pulse, 125. At the urgent request of herself and her husband I opened her abdomen, under gas and oxygen anesthesia, and removed a perforated gangrenous appendix. Drainage and no stitches. She was very sick for the next three days—considerable vomiting—needing gastric lavage; with fairly high temperature and pulse, but on the whole she made

FIG. 5.—Case of Dr. Woodworth's, Ellsworth, Wisconsin. H. O., aged twenty years, acute general septic peritonitis from perforated gangrenous appendix. Perforation forty-six hours before operation. No stitches. Three drains. Photograph taken six weeks after operation.

a surprisingly good recovery. One year later a note is made on her history sheet, "there is no appreciable hernia." The wound looks like an ordinary laparotomy wound without stitch marks. Later this woman went through one of our best known clinics and was not recognized as an operative hernia case. Two years after I had operated upon her I reopened her wound for the purpose of

correcting her supposed operative hernia. I was surprised to find a fairly good strong abdominal wound; some deep adhesions but no more than are usually found after such a recovery as hers. One of my cases, Fig. 1, was also seen first on the fourth day following her perforation, vomiting, greatly distended and very sick. Drainage of what I believed to be a general septic peritonitis and closure of the abdominal incision with adhesive strips, resulted in a stormy, slow recovery, with an excellent looking wound.

One of our last cases was a much distended woman of sixty with intestinal obstruction due to a large impacted gall-stone in her lower ileum; fecal vomiting for thirty-six hours, and a valvular vegetation embolus in her popliteal artery necessitating amputation at the knee. This woman recovered and at present has a good looking abdominal wound, although it was not stitched at all.

I have applied this same principle with great satisfaction to wounds that have been coughed or vomited open. One case in every 300 laparotomies has been my experience of the frequency of this occurrence, and I might say that no method of suture yet advised will always prevent this accident.

A recent writer, when speaking of closure of abdominal incision, thinks that primary herniæ were extremely rare in the early days of abdominal surgery when the wounds were closed by through-and-through heavy silk sutures. Perhaps he is correct, but he must remember that the mortality of the time he speaks was 25 per cent., meaning that the hernia cases of that early day did not recover to develop hernia. Subject looked up in the *Index Medicus* for the ten years 1909 1918 inclusive. No article in which it is incorporated in the title.

Numberless articles entitled "Peritonitis," "Septic Peritonitis," "The Surgical Treatment of Peritonitis," etc., but in none of the many of these reviewed was the use of adhesive mentioned or treatment without sutures.

No mention of the subject was found in several articles on the treatment of peritonitis due to war wounds.

No mention of the subject in any of the several text-books on surgery and surgical technic, except as follows:

Keen, W. W., *Surgery*, 1908, p. 719: "The skin may be closed as best suits the surgeon, by subcuticular suture, with wire, silkworm-gut or catgut, or by a continuous lock-stitch suture of horsehair, silk, etc. Aseptic adhesive plaster may be used, especially in the slanting so-called scarless incisions, but the subcutaneous tissues must be carefully sutured beforehand to prevent later stretching of the scar."

Morse, N. C., *Postoperative Treatment*, 1905, p. 65, in discussing the treatment of postoperative peritonitis, says: "Recently the suggestion has been made to remove the intestines from the abdominal cavity and forcibly scrub them. . . The suture of the incision is rarely advisable; it takes time and prolongs the anesthesia. The sides of the wound can be easily held together with the dressings."

I wish to extend my thanks to Mrs. Mellish, of the Mayo Clinic, for looking up the literature of the past ten years.

THE TREATMENT OF MALIGNANT PERITONITIS OF OVARIAN ORIGIN

By E. A. CODMAN, M.D.
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An exceptionally fortunate series of cases of the kind implied in the above title has attracted me to this subject. I trust that the observations I have made are of importance enough to report to this Society. I may be able to stimulate your interest in looking up the end-results in similar cases, and I may be able to give you hope for the hopeless.

All surgeons of experience know the type of case I mean. Clinically we find a large abdominal tumor, usually obscured by ascites and distention, and probably not more accurately diagnosed than as a case of exploratory laparotomy. On opening the abdomen there is a gush of straw-colored or blood-stained fluid. An irregular cystic mass adherent to the intestines and pelvic structures, and obscuring the accustomed landmarks, is found. Further exploration shows metastases in the omentum and peritoneum. If the operator is of a radical disposition he breaks down the adhesions, reams out cystic and solid masses of tissue, makes a bloody and disgusting mess and backs out, knowing that he has left portions of the tumor. Experienced surgeons probably back out sooner. The pathologist reports "cancer," and confuses us with his favorite nomenclature of ovarian tumors. We send sad messages to the friends, and feel some sympathy for the attending practitioner who must see the patient through the terminal stages of the disease.

My hobby for looking up end-results has led me to some

pleasant surprises in this type of case, for I find 5 cases still alive after periods of sixteen, eight, three, two, and one year respectively. Nature has been in the main responsible for these miracles but I believe that certain principles of treatment have helped.

This is not an essay on the pathology of ovarian tumors. I simply speak of the clinical picture which we all know, whether the type be papillary, colloid or true adenocarcinoma. If you wish a pathologic classification, the best I know is that of Gebhard. From the literature we learn that the colloid form is less malignant than the papillary form and the latter is less malignant than the true adenocarcinoma. In searching the literature it is easy to find references to "the well-known fact" that papillary peritoneal metastases may disappear, but I have been unable to find definite reports of such cases, nor even the original authority for this statement. Bland-Sutton says: "It has been clearly established that when the abdomen has been opened for the removal of a papillomatous cyst, the peritoneum has been found studded with warts. A few years later the abdomen has been opened and all the peritoneal warts have disappeared."

But neither Bland-Sutton nor the other authorities give satisfactory instances, and none, with the possible exception of Hofmeier (mentioned by Pfannensteil), give any report of the disappearance or retrogression of true adenocarcinoma.

The following 5 cases which have come under my personal observation seem to me worth reporting, as the pathologic specimens are all preserved in the laboratory of the Massachusetts General Hospital:

Case I.—E. S. Records, vol. 372, p. 76. A woman, aged thirty-two years, was operated on by my chief, Dr. F. B. Harrington, at the Massachusetts General Hospital on June 30, 1900. Under the diagnosis of pelvic abscess an incision was made in the vagina, some papillocystic material was curetted out and drainage established. Nine days later, at Dr. Harrington's suggestion, I opened the abdomen and found a large inoperable pelvic mass, and diffuse wart-like metastases scattered over the whole peritoneum.

From year to year this patient returned to the hospital seeking radical operation and was considered hopeless by the various surgeons to whose services she was admitted. The vaginal sinus persisted and discharged pus and occasionally lumps of necrotic malignant tissue. Although the tumor grew, her general condition improved.

Finally, on December 22, 1910, ten years after the original operation, I was persuaded to attempt another. To my surprise, on opening the abdomen, I found the peritoneum perfectly free from metastases and the growth limited to the huge pelvic tumor which was adherent to the neighboring structures. After a sort of nightmare operation, I succeeded in removing the entire tumor with all the pelvic organs, including the rectum. An artificial anus was made. After a tedious convalescence the patient recovered, and when last seen on August 14, 1916, was fat and well—six years after the second operation and sixteen after the first.

All pathologic specimens showed typical papillary cystadenoma. The large tumor was more solid than cystic.

Case II.—E. S. Records, vol. 664, p. 327. A negress, aged twenty-three, was operated on by me at the Massachusetts General Hospital on December 9, 1909. An inoperable pelvic tumor and numerous peritoneal metastases were found. A specimen was taken from the peritoneum and reported to be adenocarcinoma. She made a good recovery, and in June, 1916, her physician reported that she was well and had since married. A small pelvic tumor still existed six and one-half years after the first operation.

On May 27, 1918, her physician, Dr. C. P. McClendon, of New Rochelle, N. Y., wrote: "I have just returned home and found your letter making inquiry about R. M. I am happy to state that she is in very good health. And the trouble of which she complained when I last wrote to you seems to have subsided. She seems to be in excellent health. She is sometimes troubled with periods coming on twice a month, but seldom complains of the sharp pains as she used to. She is not willing to be operated and so I just look her over at odd times."

Case III.—Codman Hospital, Case 270. July 22, 1915. Female, aged sixty-two years. An abdominal tumor larger than full-term uterus. Pre-operative diagnosis—ruptured papillomatous cyst of ovary.

Operation (E. A. C. and A. R. B.). Large multilocular cyst It had been ruptured to some extent, and the jelly-like contents had spread about abdominal cavity and in places had become encysted again. The tumor was removed and was found to consist of numberless spaces filled with colloid material, but there were no papillomata—only thin walls. Nevertheless, on section, Dr. J. H. Wright considered the specimen colloid cancer.

Complications. None.

May, 1918: Her physician reports by telephone that there is no sign of recurrence.

Case IV.—Codman Hospital Case No. 308. March 13, 1916: Female, aged fifty-five years. Abdominal tumor extending from pelvis 2 inches above umbilicus. Pre-operative diagnosis fibroma of uterus, or cystoma of ovary.

Operation (E. A. C. and A. R. B.). Tumor proved an extensive malignant mass involving all pelvic organs and invading peritoneum with little tubercles. Piece of peritoneum excised and reported adenocarcinoma (psammoma) by Dr. Wright. Condition considered inoperable and abdomen closed.

On reflecting on this case, it occurred to me that as the tumor was evidently partly cystic, it might be possible to obtain through-and-through drainage, and to treat the tumor with radium from inside out, through the pathway thus obtained. The patient's relatives were, therefore, sent to consult Dr. H. A. Kelly of Baltimore, Dr. John G. Clark of Philadelphia, Dr. Francis D. Donaghue, and Dr. R. B. Greenough of Boston, to see whether such an operation would be justifiable, and it was advised that the attempt should be made, although no precedent existed.

On March 22, I operated again and carried a large rubber tube through the mass from the abdomen out through the vagina. By introducing radium (obtained through the courtesy of the Huntingdon Hospital) through this tube, a thorough course of treatment was given.

To my great astonishment the bulk of the tumor vanished, so that at the time of her discharge on July 29, there was only a small pelvic mass left. From being almost moribund, her condition had become one of almost perfect health.

After this she received several external radium treatments at the Huntingdon Hospital (No. 16,148) which were unfortunately followed by a severe burn of the abdominal wall, from which she suffered a great deal.

On March 21, 1917, she re-entered for treatment of the radium burns, which proved so intractable that I decided to excise them. At this time her general condition was excellent, and the only remains of the original tumor was an irregular pelvic mass occupying about half the pelvis.

Operation (April 10, 1917) (E. A. C. and G. A. Leland, Jr.). The burns were excised and the abdomen opened. The pelvic mass seemed operable, and after a five-hour operation, I succeeded in removing it with the uterus and adnexa. To my great surprise the peritoneum now showed no trace of disease, and the uterus and its adnexa, which previously were indistinguishable in the cancerous mass, were now plainly recognizable, although adherent. The disease seemed wholly confined to the ovaries, which measured $7\frac{1}{2} \times 6\frac{1}{2} \times 4$ cm. and $8 \times 6\frac{1}{2} \times 5$ cm., respectively. Vaginal drainage was established, and the abdominal wound was closed. The appendix, which contained a concretion, was not removed. Microscopic examination showed that the ovarian tumors resembled the original tumor, but the cells showed no mitoses. In the abdominal scar a few small areas of disease were also found.

Complications. An abscess in the abdominal fat and a very small rectovaginal fistula.

Result (May 15, 1918). The patient is well and has gained much flesh. There is no evidence of recurrence. She still has some trouble with a second small radium burn which appeared six months after the last radium treatment.

It is interesting to note also that a small pedunculated fibroid tumor which was present at the first operation was removed at the

last operation. It showed no apparent change in size, in spite of the energetic radium treatment.

I attribute the favorable outcome in this case to the following factors:

1. The tumor could be treated from within outward.

2. The calcareous deposits by the cancer cells indicated that there was a tendency toward replacement of cancer tissue with lime salts.

3. The calcareous atoms set up secondary radiation.

4. The toxic products of destruction could be drained away.

5. The patient had already shown that she could develop a very large malignant tumor without producing general cachexia.

6. The patient herself showed indomitable optimism and courage.

CASE V.—Codman Hospital Case No. 408. Female, aged sixty-three years. An abdominal tumor the size of a six months' uterus.

Operation. (August 28, 1917) (E. A. C. and H. V. Andrews). Free brownish peritoneal fluid. Tumor mass adherent in pelvis, partly cystic and partly solid. Peritoneal metastases—some even as high as right renohepatic region. Cysts evacuated and partitions broken down so that rubber tubes could be placed for the use of radium. Both ovaries probably involved.

Postoperative treatment with radium as in Case IV.

May 31, 1918. Patient is well and strong, although an irregular pelvic tumor is still present with sinuses through which radium treatment is occasionally given.

The section shows papillary adenocystoma of the usual type.

Although this patient has been only nine months since the operation, I consider her progress excellent and plan to do the second operation in a few months, hoping to find, as in the other cases, that the peritoneal involvement has disappeared.

In order to have some idea of what the usual outcome of such cases is, I determined to try to trace all similar cases which had been operated on at the Massachusetts General Hospital in the last twenty-five years. This privilege was granted me by the

gracious consent of my former colleagues at that hospital. I found 41, excluding all cases which died in the hospital after operation, and all cases in which the records did not give what I considerate adequate proof of the existence of a malignant or papillary peritonitis at the time of operation, and also my own cases. I succeeded in tracing all of these. (This speaks pretty well for the records of the Massachusetts General Hospital I think.)

All but two of these 41 cases died of the disease. These two were of the colloid type—one living at least nine years and the other over four years. One of the colloid cases is worth recording.

Massachusetts General Hospital. E. S. Records, vol. 546, p. 165. The peritoneal cavity was filled with greenish jelly-like substances. A large multilocular cyst was removed and a hernia, following a previous laparotomy, was repaired. Several small cysts filled with jelly-like substances were found in the scar tissue. The pathologic specimen showed the characteristic appearance of colloid carcinoma even in the abdominal scar. The abdomen was washed out with weak soda solution as thoroughly as possible. Patient had an uneventful convalescence.

January 22, 1907, she re-entered the hospital, stating that she had been comfortable until four days before, when pain, suggestive of gall-stones, occurred. There was a mass the size of an orange in the right hypochondrium which was exceedingly tender. She was operated on by Dr. F. B. Harrington who found the "peritoneal cavity largely obliterated by adhesions and soft gelatinous tissue; liver completely hidden by these adhesions. Gall-bladder not found and search not persisted in. Bit of omentum and gelatinous tissue removed for pathologist" (reported inflammatory).

Patient had complete relief from her pain and normal convalescence.

She again entered the hospital on December 11, 1915, having in the meantime been operated on at the Boston City Hospital, under a diagnosis of intestinal obstruction. We were informed that at the laparotomy dense adhesions were found about the liver, and gall-bladder could not be located.

She now complained that for the last month she had had attacks characteristic of gall-stones and again had tenderness in the right upper quadrant. On December 18, 1915, Dr. D. F. Jones operated and found dense adhesions, but there was no mention in the report of gelatinous material. Some small stones were removed from the gall-bladder. She had a normal convalescence.

On January 7, 1917, she reported as being partially relieved.

I have been told by Dr. R. B. Greenough that she has recently had another operation for ventral hernia.

It seems to me that this case shows evidence that the presence of colloid material, such as found at the second operation, does not necessarily mean hopelessness. Unfortunately, the bit of omentum excised was not a satisfactory proof of the existence of epithelial cells at that date.

The others died at the following periods: Of the total, 39, 12 died in less than two months after operation; 19 died in less than six months after operation; 29 died in less than one year after operation; 33 died in less than two years after operation; 39 died in less than four years after operation. In other words, 30 per cent. died in less than two months and 74 per cent. in less than a year. These are rough figures but are conservative. They show that as a rule the condition is rapidly fatal.

We may conclude from that that such cases usually die within a year after coming to operation. Nearly all of them were operated by competent surgeons, members of this Association. However, my own 5 cases seem to show beyond doubt that the peritoneum has the power to kill and replace cancer cells under certain conditions. The observations made in these cases have led me to indulge in some speculations in regard to cancer in general which may be of interest to you.

How does cancer kill? In a general way (1) by erosion, as in the case of a rodent ulcer which actually eats its way into a vital structure. This is rare. How few cases any one of you can actually recall! (2) By perforation of a vital structure, as of the stomach or intestine. This is more common but still rare. A

preperforative sealing process usually prevents it. (3) By stricture of some vital organ, as in the case of obstruction of the intestine. Even this is amenable to timely surgery. (4) By mass pressure causing pressure on some vital structure, as in the case of extensive disease of the lungs. (5) By cachexia. This you will admit is the common cause, and usually the precursor of the other causes. To be sure, occasionally one sees a case die from erosion of a great vessel, the perforation of a viscus, from occlusion of the intestine or ureters, or from intracerebral pressure before any cachexia has appeared, but you must agree that in the vast majority of cases there is also a severe cachexia present. And will you not agree also that if we could prevent cachexia, we could prolong many lives indefinitely, and also cope fairly well with these other more mechanical conditions of erosion, obstruction, perforation and pressure, which we handle after a fashion as it is?

What makes metastases? It is a platitude to remind you that cancer tends to grow. If the growth is under pressure in the interior of the body, is it not more likely to metastasize than if it is external? External cancers may last for years and give rise to no cachexia whatever. The two most benign forms of cancer are rodent ulcer and papilloma. In the one case the cells soon lose their vitality when exposed to the air and are wiped off by any light friction. In the other they grow outward in grape-like clusters, but in neither case do they cause cachexia or metastases, until their base has invaded the subsoil. In other words, the poison which would be absorbed by an internal growth is drained off and the internal pressure of the growth goes outward, sloughing off in the rodent ulcer, and hanging free in papilloma. Observe that papilloma is a typical growth in the hollow viscera—of the bladder, of the intestine and sometimes of the stomach. Histologically it is hard to tell whether it is benign or malignant in a given case. I believe the answer in each case could be given if we knew the direction of lower mechanical pressure in the deepest cell. This would determine whether the next cell would be cast off into the outer world or into the lymph- or blood-stream. If the latter, it would mean danger of metastases and

cachexia. If the former, it would mean freedom from absorption of the poison or spread of the disease.

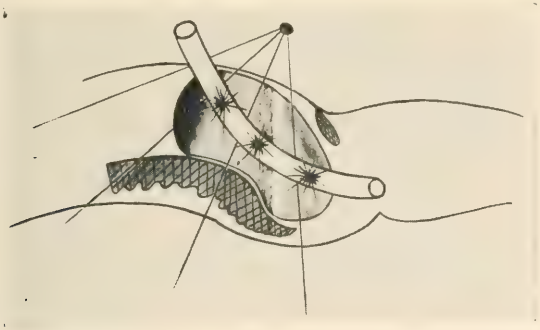
Now how about the ovary? Here we have papillary cystadenoma as the type tumor. Cysts develop with papilloma in them. The growth is hardly external or internal. Though inclosed, the direction of least resistance is toward the peritoneal cavity. Cysts form faster than their papillomatous contents. While this goes on they are benign. When the solid cellular part gets the upper hand they become malignant. When the growth of a papillary cystadenoma adding cell by cell reaches a certain point of tension from internal pressure, some cells are forced through the fibrous envelop and protrude on the peritoneal surface. As these little tumors add more cells, their terminal ones drop into the free peritoneal cavity, lodge and take superficial root. They become peritoneal metastases. Sometimes this process is rapid, because some external trauma ruptures the cyst and the cells are seeded through the whole peritoneum.

In other cases the peritoneal metastases are rather of the nature of direct extension of tumor cells along the peritoneal lymphatics, and are seen as minute whitish tubercles radiating from the pelvic peritoneum upward. Such cases are true adenocarcinoma if I may judge by Cases II and IV. In others, colloid spaces are found in the meshes of the omentum. But in all of these three kinds of metastases the peritoneum indubitably may triumph.

We know the wonderful power the peritoneum has in dealing with sepsis and with tuberculosis. Who has not marvelled at seeing the smooth shining surface of the peritoneum, in some case, at a second operation, which a few weeks earlier he saw red and turgid with an angry inflammation. And the return to normal after severe tuberculous involvement is now almost expected. I believe that you may also look for such results in a small proportion of your malignant cases. If my experience has met so many, surely the fact must be that other such happy results are occurring at other clinics, if the cases be followed up.

Now is my own lucky experience due to my treatment in any

way? Case I made me feel that drainage was perhaps the cause. It suggested that furnishing a direction of least resistance and permitting free drainage might prevent metastases and cachexia. Case II showed the tendency of nature in exceptional cases to do much unaided. Case III showed the value of hope when artificial drainage, nature and radium were united to do their best with one object in view. Surgery acted a subordinate part in two cases (I and III) by removing what the other agents had localized. Case V is bearing out my theories. She has no cachexia.



Perforated drainage tube to allow: (1) repeated introduction of radium; (2) drainage of poisonous by-products (cachexia); (3) direction of least resistance for the pressure incident to growth; (4) lymph to go out through the tumor instead of back into the system; (5) the periphery of the tumor to constantly approach the radium.

The accompanying figure is offered to show you at a glance how my present ideas of the proper treatment are summarized.

In conclusion let me set down these facts and principles, for I believe the observations made in these cases justify them.

Facts. 1. The peritoneum has a special power of resistance and repair after diffuse infection with septic organisms or tubercle bacilli, and in a minor degree, after diffuse invasion with cancer cells of ovarian origin.

2. It is possible for nature unaided to cause the retrogression of peritoneal metastases and the gross limitation of a diffuse malignant condition into operable tumors.

3. Radium which is known to be the most efficacious in those new growths which are clinically most benign, may also aid the peritoneum in a battle which otherwise is ony slightly in favor of the growth.

Principles. 1. The most malignant characteristics of cancer are: (1) Its insistence on growth. (2) Its absorbable poison which produces cachexia. (3) Its tendency to metastasize. Beyond these three mysterious characteristics it has only mechanical terrors. Even these mechanical terrors would be controllable to a large extent by ordinary surgery, for we can do plastics on erosions, suture perforations and remove mass pressure.

2. Therefore, the treatment of cancer in general should aim at (*a*) providing a direction of least resistance for the growing cells, (*b*) at conducting the growth toward a point at which we can bring its enemy, radium, to meet it, (*c*) at maintaining the fluid lymph-flow from the rest of the body, out through the malignant tissue, so that the cachectic poison will be released instead of being absorbed.

3. Ovarian disease lends itself peculiarly to this treatment because it is papillomatous in type, has a large fluid draft, and clinically is known to have a mild cachexia since it grows to enormous size without materially affecting the general health. Also it seems to have a low metastasizing power. Normal ovarian tissue is known to be especially sensitive to radiant energy.

I hope that when you next run across one of these hopeless cases, you will at least, give these theories of treatment a trial. Personally, I believe they form rational principles for the treatment of cancer in general.

LIGATION OF THE ABDOMINAL AORTA: LIGATION OF THE FIRST PORTION OF THE LEFT SUBCLAVIAN.

By C. A. HAMANN, M.D., F.A.C.S.
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THE purpose of this communication is to record a case of ligation of the abdominal aorta and one of the first portion of the left subclavian artery, together with brief comments on the same.

CASE I.—Ligation of the abdominal aorta, just above its bifurcation, for a pelvic tumor, mistaken for an aneurysm; survival of patient for six months without gangrene of the extremities. Death due to hemorrhage from bed-sore.

J. B., aged fifty-one years, entered the Cleveland City Hospital March 28, 1916, complaining of pains in the lower extremities, partial paralysis, and loss of control of the bladder and rectum.

There are no facts in his family or personal history that bear upon his present illness, which began five or six years ago, with pain in the calf muscles of his right leg, subsequently involving the toes and region of the hip. Various forms of treatment were resorted to without benefit. His right lower extremity became useless. In May, 1915, the right great sciatic nerve was stretched; no improvement resulted. Later his left leg became painful and partially paralyzed, and he was confined to bed after September, 1915. Subsequently incontinence of urine and feces developed. About this time the Wassermann reaction (blood and cerebrospinal fluid) gave negative results.

Physical Examination. Patient was a poorly nourished man, whose general appearance was indicative of long-continued

suffering. There was a large pulsating mass, occupying the pelvis. The right gluteal region was prominent and there seemed to be distinct, eccentric pulsation. Upon rectal examination the mass was readily felt; it was tender and pulsated strongly. A to-and-fro murmur, as it was called by the recorder, was heard over the mass. The lower extremities were atrophied; there was paralysis of the extensor muscles of the right foot. The lower part of the abdominal wall was hyperesthetic; the buttocks, scrotum and part of the right lower extremity was anesthetic. The knee-jerks were exaggerated. There was incontinence of urine and feces.

It was obvious that the pelvic tumor was the cause of the symptoms, and the question as to the nature of the tumor was an interesting one. Various examiners called it a sarcoma, others an aneurysm. It seemed to me to be an aneurysm, and as it apparently involved the right internal iliac or its branches, I advised ligation of this vessel, which was done on April 4, 1916. When the abdomen was opened the internal iliac at and near its origin was found to be normal, and as it was believed that its branches were involved, the vessel was tied with chromicized catgut. Pulsation in the tumor ceased for some days only, and the patient was not relieved.

By September, 1917, the pulsating mass had increased in size and could be felt on the left side. Ligation of the aorta was proposed to the patient, and he acquiesced.

September 11, 1917, the aorta was tied with heavy braided silk, about a half inch above the bifurcation. The ligature was tied so firmly as to divide the intima and media, as nearly as could be determined. The coats of the vessel seemed normal. The pulsation in the pelvic mass at once ceased and never returned The lower extremities were wrapped in cotton to maintain warmth. Seven hours after operation the patient complained of burning pain in the limbs; subsequently there were not observed any motor or sensory phenomena of consequence. There was no disturbance of the renal function. On the third day after operation a faint pulsation could be detected in both femoral arteries. There never was any evidence of gangrene of the toes except that,

as the result of a burn from a hot-water bag, the distal phalanx of one great toe became necrotic and, after separation the stump healed over. On the whole there was considerably less pain in the extremities after the operation, and he was able to move them better. Over the sacroiliac region, posteriorly there gradually appeared pulsating vessels, evidently a part of the collateral circulation. Pressure sores appeared on the heels, and a previous bed-sore became gradually deeper. One leg was amputated in the lower third with a view to relieve him of the heel pain; the wound never united. He began to bleed from the bed-sore, and died March 31, 1918, six months after the ligation of the aorta, following a rather severe hemorrhage from the bed-sore.

Autopsy. The pelvis was filled with a large, solid tumor, five or six inches in diameter; there were metastases in the liver. Histologically the growth was found by Dr. Howard T. Karsner to be a carcinoma, in which the tissue resembled the structure of the thyroid gland. (There had not been observed any enlargement of the thyroid and the gland was not examined at the autopsy.) The diagnosis of aneurysm had, therefore, been wrong. The aorta was constricted by the ligature, which was still in place and embedded, but was not obliterated, there being an opening less than three-sixteenths of an inch in diameter; the vessel was normal in caliber above the ligature, as were also the common iliacs. The lumen of the right internal iliac had also been partially restored.

The main points of interest in the above case would seem to be the following: (1) The fact that the patient lived six months after ligation of the abdominal aorta just above the bifurcation, without the appearance of gangrene of the extremities; (2) The partial restoration of the lumen of the vessel after apparent complete obliteration by a firmly tied silk ligature; (3) the reappearance of the femoral pulse on the third day.

Inasmuch as the aorta was not found to be completely obliterated, in this case, it can hardly be said that proof is afforded that collateral circulation can develop after ligation of the aorta to a sufficient extent to prevent gangrene. In both Keen's and

Tillaux's cases, which lived respectively forty-eight and thirty-nine days, there was found a lumen at the seat of ligation, so that these cannot, in my opinion, be adduced as proof that collateral circulation can develop sufficiently after complete and permanent obliteration of the lumen of the aorta; furthermore, the complete obliteration of the lumen would probably sooner or later result in cutting through of the ligature, and death from secondary hemorrhage.

The reason for the incomplete obliteration of the lumen of arteries by ligation is to be sought, in the majority of instances in the slipping of the first turn of the knot, before the second one is tied, as Ballance and Edmunds point out.

It is my belief that ligation of the aorta below the origin of the inferior mesenteric is a justifiable procedure in cases of iliac aneurysm, for instance, and that it affords fair chances for recovery and cure.

The abdominal aorta has been ligated sixteen times as near as I have been able to learn. Most of the patients died soon after the operation. Tillaux's patient lived thirty-nine days, Keen's patient forty-eight days and the one above recorded six months. Guinard reports a case of ligation of the thoracic aorta distal to an aneurysm of the arch; the patient died of an anuria, as is to be expected if the ligature is applied above the renal arteries.

Ligation of the First Part of the Left Subclavian Artery. Mr. E. R., aged fifty years, had an aneurysm, about one inch in diameter, involving the third portion of the left subclavian artery,which had been noticed for about one year; there, were no marked evidences of pressure on the vein or nerves though he had some pain. Wassermann reaction negative. There was a moderate degree of arteriosclerosis, and the arch of the aorta was somewhat dilated.

He was operated on at Charity Hospital, May 10, 1917.

The third portion of the artery was exposed by the usual incision, and it was found that the dilatation extended beneath the scalenus anticus; this muscle was therefore divided after displacing the phrenic nerve. The subclavian and internal

jugular veins and thoracic duct and vagus nerve were held aside and the first portion of the artery well exposed; it was somewhat dilated. A double ligature of braided silk was passed around the vessel and firmly tied. Pulsation in the sac ceased at once and did not return.

The wound healed *per primam*, and there were no disturbances in the circulation of the upper extremity, except for the absence of the pulse beyond the ligature. The sac contracted into a small firm mass, and when last seen, four or five months afterward, the patient was quite well.

In this case the branches of the subclavian were not tied, as has been suggested and practised by a number of surgeons, in order to lessen the dangers of secondary hemorrhage.

The literature of ligation of the subclavian has been reviewed, and statistics collected by a number of writers, reference to whose articles are given below.

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DISCUSSION

Dr. James E. Thompson, Galveston:

I wish to discuss one point only in reference to Dr. Hamann's paper, and that is in reference to the reëstablishment of the lumen of the artery after ligature. I believe after ligature of the larger vessels that it is probably quite a common result. It occurred in Dr. Hamann's case of ligation of the abdominal aorta and I am under the impression that it has been reported previously in the ligature of large vessels.

Some few years ago I reported a case of ligature of the innominate artery in the *Annals of Surgery*. A chance was obtained in this case to examine the innominate artery at the site of the ligature. Obstetrical tape had been used for the ligature material. The patient had recovered from the immediate operation and the aneurysm (subclavio-axillary) had been cured. We found that the lumen of the innominate artery had been restored, a small aperture existing which admitted the end of a medium-sized probe.

CYLINDRICAL DILATION OF THE COMMON CAROTID ARTERY FOLLOWING PARTIAL OCCLUSION OF THE INNOMINATE AND LIGATION OF THE SUBCLAVIAN

By W. S. HALSTED, M.D.
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The following unique observation confirms, on the human subject, the discovery made on dogs that a partially occluding band may cause a distal dilation of the artery,[1] and probably sheds light on the pathogenesis of the aneurysms of the subclavian which occur in cases of cervical rib. It may, furthermore, help to explain the dilatation of the arterial trunk, which I find from the perusal of about 400 reports has quite frequently been noted on the cardiac side of arteriovenous fistulæ,[2] and which, in our own clinical and experimental cases, has occurred invariably; and conceivably it may eventually lead to the discovery of a law or laws governing the preservation of the

[1] Halsted and Reid: An Experimental Study of Circumscribed Dilation of an Artery Immediately Distal to a Partially Occluding Band, and its Bearing on the Dilation of the Subclavian Artery Observed in Certain Cases of Cervical Rib. Ibid: Partial Occlusion of the Aorta with the Metallic Band. Observations on Blood-pressures and Changes in the Arterial Walls. Jour. Exp. Med., 1916, xxiv, 271, 287.

[2] William: Hunter, was first to describe an arteriovenous aneurysm, He noted in his first and second Cases what so many surgeons have since overlooked, that the artery concerned becomes dilated proximal to the fistula. Ibid. The History of an Aneurysm of the Aorta, with Some Remarks on Aneurysms in General. Medical Observations and Inquiries, 1757, i, 323. Ibid.: Further Observations upon a Particular Species of Aneurysm, Medical Observations and Inquiries, 1762, ii, 390.

integrity of the arterial wall and thus to the better interpretation of certain pathological phenomena of the vascular system.

Mrs. B., aged fifty years (Surg. No. 18357), was admitted to the Johns Hopkins Hospital October 17, 1905, suffering from a large aneurysm of the right subclavian artery (see Fig. 1).

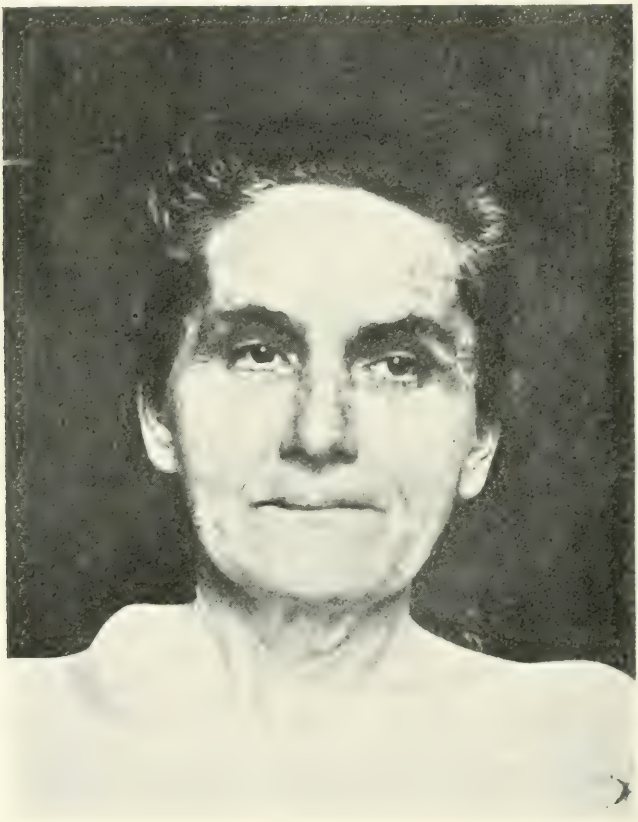

FIG. 1.—Mrs. B——, November, 1905. Aneurysm of the right subclavian artery.

November 17. *First Operation.* An aluminum band was applied to the innominate artery and tightened until the pulse in the aneurysm was almost completely obliterated.

January 12, 1906. *Second Operation.* The constriction of the innominate artery having, apparently, uninfluenced the aneurysm an attempt was made to excise it. Enucleation, almost accomplished, was not completed because the sac could not be freed from the subclavian vein. Hence, the subclavian artery was ligated in its first portion close to its origin from the innominate and in its third portion on the confines of the axillary artery. Both of the ligatures were tied quite close to the aneurysm, which had been so thoroughly freed in the course of the dissection as to make their application easy. Pulsation in the aneurysm was completely interrupted for a few minutes only. Temporary occlusion of the right common carotid, which was normal in size, seemed to be without influence either before the subclavian was ligated or after the return of pulsation in the sac subsequent to the ligations. A light plaster-of-Paris dressing, completely concealing the feebly pulsating aneurysm, was applied.

Ten days later (January 22, 1906) the cast was removed and the aneurysm, to my surprise, found to be pulseless, although little if any smaller.

December 14. Patient returned for observation. Dr. Sowers noted a slight systolic bruit distal to the band and a "rumbling systolic bruit" on the proximal side of the constriction.

April 2, 1909. There is a circumscribed, hard, non-pulsating nodule, about the size of a Madeira nut, at the site of the late aneurysm. Pulse in the radial artery is palpable. No disturbance of sensation or motion is complained of. Patient states that her health is excellent and that she has not been annoyed by the loss of the clavicle and part of the manubrium. The right common carotid is dilated to about twice the normal size throughout its entire length. There is, however, no suggestion of a circumscribed, aneurysm-like dilatation. The innominate artery, proximal to the band, is not enlarged.

March 31, 1911. Note by Dr. Heuer: The carotid pulsates strongly just above the level of the clavicle. This vessel is dilated, having a diameter of about 2.5 cm. There is still a

little mass, non-pulsating, at the site of the former aneurysm.[1] No pulse can be felt in the right radial or right brachial. The

FIG. 2.—Mrs. B——, February, 1918. Twelve and a half years after the application of a partially occluding band to the innominate artery and ligation of the right subclavian artery in its first and third portions. Distal to the band the innominate and carotid arteries are dilated. (Outlined by Dr. W. F. M. Sowers.)

[1] Thus five years and three months after the cure of the aneurysm a trace of the tumor remained.

right hand is a little colder than the left, but there is no swelling of the arm, forearm or hand.

March 16, 1917. Note by Dr. Sprunt: There is marked inequality of the radial pulses, the right being the smaller.

February 15, 1918. Note by Dr. Reid: Patient has come from her home in Washington for demonstration at Dr. Halsted's clinic. She states that she is perfectly well and has no abnormal sensations. Pressure over and just above the band

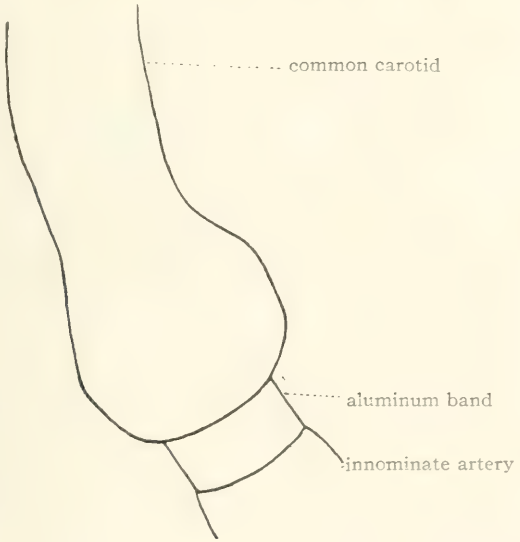

FIG. 3.—Mrs. B——, February 15, 1918. Diagram, actual size, made from Dr. Reid's measurements.

compels a cough. The right hand seems as strong as the left and the sensation of a cold right hand, of which she was formally conscious, has altogether vanished. The last trace of the old aneurysmal sac is gone. The band is definitely though indistinctly palpable. There is a marked dilation of the right common carotid from the band to the bifurcation (see Figs. 2 and 3). Below the band one can trace the innominate artery for a short distance; it is certainly not dilated in the proximal portion.

The dilation of the carotid is somewhat fusiform at its central end. The greatest width of the artery (2.8 cm.) is about 1 cm. above the upper edge of the band. From this point (Fig. 3, *b*) the diameter diminishes rather rapidly, losing 1 cm. in an equal stretch of the vessel, which then maintains an almost cylindrical but slightly tapering form to the bifurcation (see Fig. 3). The innominate, which at the operation was considerably constricted by the metal tube, is now smaller below than above it—smaller probably than normal. A distinct bruit,

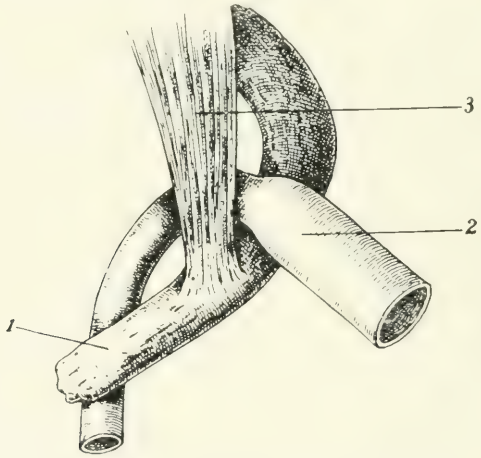

FIG. 4.—1, cervical rib; 2, subclavian artery dilated distal to the site of constriction; 3, scalenus anticus muscle. (Reproduced by the courtesy of Dr. W. W. Keen and the editor of the American Journal of the Medical Sciences.)

audible along the whole course of the right carotid, is loudest just above the band. It is not heard below it, over the innominate. Pressure here on the innominate obliterates the pulse in the carotid. The blood is surely coursing through the aluminum tube. The heart is not demonstrably enlarged nor is the aorta. The right radial pulse is feeble, but easily countable. Its systolic pressure is 80+; the diastolic pressure cannot be accurately determined. In the left arm the blood-pressure is 180/90.

Thus on the human subject we have now a striking confirmation of the observations which Dr. Reid and I have made upon the aorta of dogs. Four or five times in the past twelve and a half years this most obliging of patients has journeyed to Baltimore in response to my letters, and nine years ago I made a note of the remarkable manifestation—a cylindrical dilation of the common carotid throughout its entire length. But not

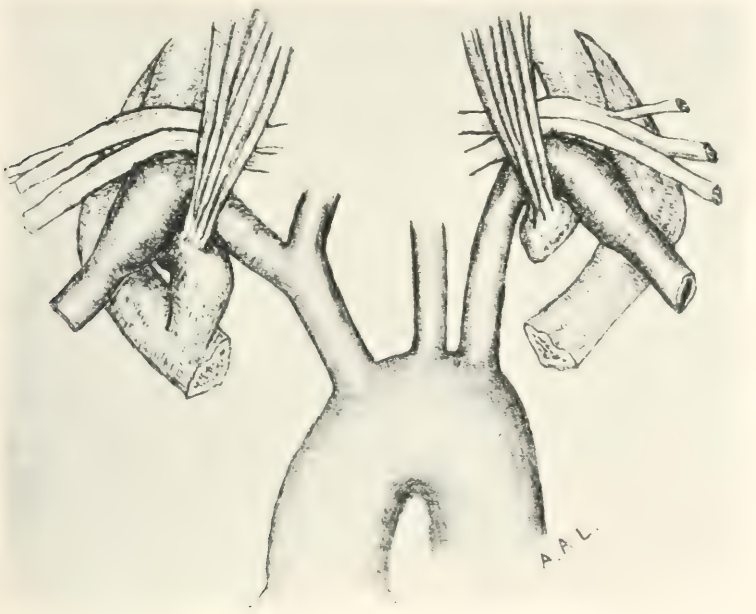

FIG. 5.—Dilation of the right and left subclavian arteries above the cervical ribs and distal to the site of constriction. (Reproduced by the courtesy of Dr. Arthur A. Law and the editor of the Journal-Lancet.)

until this year did the explanation of the phenomenon occur to me, although for many years I have pondered the subject of the dilations distal to the point of constriction in cases of cervical rib, and four years ago observed for the first time a dilation of the aorta, distal to a partially occluding band, in the dog (see Fig. 8). How true it is for some at least that facts may almost strike us in the face and still pass unobserved.

In the analysis of 525 clinical cases of cervical rib I found 106 in which the subclavian artery had been compressed, and that in 27 of these aneurysm or dilatation of this vessel distal to the site of constriction had been noted. Interesting illustrations appear in the papers of Keen[1] and Law[2] (see Figs. 4 and 5).

Dilatation of the Heart in Cases of Arteriovenous Fistula. A particularly interesting result of our clinical and experimental studies of arteriovenous fistula is the discovery that enlargement of the heart probably occurs after a time, as a rule, in the major cases. My attention was forcibly called to this complication some ten years ago by a case of fistula of the femoral vessels which I saw in consultation with Dr. James F. Mitchell, of Washington, and upon which together we operated in the Providence Hospital. The phenomenal enlargement of the heart must, I thought, have been due to the fistula, and have been secondary to the enormous dilation of the aorta and vena cava. Since then we have more carefully noted the condition of the heart in our cases of arteriovenous aneurysm and have, I believe, quite invariably found it enlarged—strikingly so in several instances. If the assumption is correct that the heart dilates in consequence of the fistula it is important that the fact should be brought to the attention not only of surgeons but also of pathologists and internists who apparently have altogether overlooked it. Dr. Mont Reid has in preparation a report upon his experimental and clinical work in arteriovenous fistula in which he will offer convincing experimental proof of our view that the fistula may in its consequences profoundly affect the heart as well as the veins and arteries; and Dr. Cure L. Callander is making a careful study of all the reported cases of arteriovenous fistula in order to weigh the clinical evidence bearing on this subject which these records may furnish.

When a causative relationship between arteriovenous fistula

[1] The Symptomatology, Diagnosis and Surgical Treatment of Cervical Ribs, Am. Jour. Med. Sc., Philadelphia, 1907, cxxxiii, 173.

[2] The Surgical Aspect of Cervical Ribs, Journal-Lancet, Minneapolis, 1914, xxxiv, 330.

and dilation hypertrophy of the heart shall have become convincingly established we may find that some unexplained dilations of the heart are referable to hitherto undetected changes in the walls and lumen of the bloodvessels. That a very considerable dilation of bloodvessels may be overlooked at autopsy our experiments in the partial occlusion of arteries has convinced us. It is impossible to estimate the amount of dilation of either an artery or a vein in its collapsed state. Arteries as well as veins which, when empty, give no indication of increase in caliber may, on injection, prove to have been markedly dilated. All surgeons know how true this is of veins. A vein to which, when full of blood, von Langenbeck in deference would, as he said, remove his hat, might, when empty, be hardly recognizable in the course of an operation.

There may be more or less circumscribed aneurysmal expansions in the continuity of the otherwise cylindrically dilated, proximal arterial trunks. I have observed this in two or three of my patients. One such expansion is shown proximal to the fistula in the postmortem specimen of a famous case reported by Osler[1] (see Fig. 6) and another in Eisenbrey's[2] particularly interesting illustration (see Fig. 7). I am quite sure that in Osler's case there was a much greater dilation of the artery above the aneurysm and between the aneurysm and the fistula than the drawing indicates, for, as I have said, one cannot judge of the size of the lumen from the appearance of the empty vessel. It would interest Sir William to compare the very similar drawings illustrative of the two cases, his own and Eisenbrey's, as the latter's proves that the fistula may be a considerable distance below the point at which the artery has become conspicuously dilated and thus offers strong presumptive evidence that the

[1] Case of Arteriovenous Aneurysm of the Axillary Artery and Vein of Fourteen Years' Duration, Ann. Surg., Philadelphia, 1893, xvii, 37. Ibid.: An Arteriovenous Aneurysm of the Axillary Vessels of Thirty Years' Duration, Lancet, London, 1913, ii, 1248. Makins, G. H.: Surgical Experiences in South Africa, 2d ed., 1913, p. 148.

[2] Arteriovenous Aneurysm of the Superficial Femoral Vessels, Jour. Am. Med. Assn., Chicago, 1913, lxi, 2155.

reason why the specimen of the former lacks the evidence of the fistula is because it was too greatly curtailed by the pathologist. The pathologist, by the way, should not be too harshly censured for missing the key to the situation, for if, perchance, he had

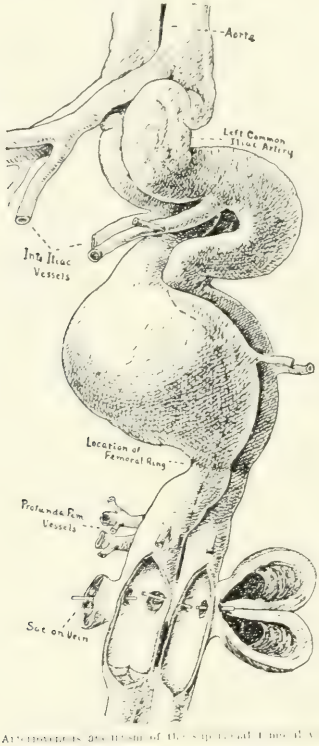

FIG. 6.—Dilation of the external and common iliac arteries and veins proximal to a fistula of the superficial femoral vessels. (Reproduced by the courtesy of Dr. A. B. Eisenbrey and of the editor of the Journal of the American Medical Association.)

been aware that the artery should be dilated central to the fistula he could hardly by any possibility have known that it might retain approximately its normal caliber for a distance so far from the arteriovenous communication.

Thanks to the assistance of highly competent secretaries I

have abstracts of 380 cases of arteriovenous fistula. These have been studied with special reference to occasional observations on the dilation of the artery. In 52 instances proximal

FIG. 7.—"Dilation of the axillary artery and vein proximal to a fistula of thirty years' duration. *S.A.M.*, scalenus anticus muscle; *I.M.A.*, internal mammary artery; *B.P.*, brachial plexus; *A.A.*, axillary artery; *A.V.*, axillary vein; *C.V.*, cephalic vein; *T.A.A.*, thoracico-acromial artery." (Reproduced by the courtesy of Sir William Osler and the editor of the London Lancet.)

dilation of the arterial trunk has been noted. In 11, dilation was mentioned, but whether proximal or distal or both is not specified. I am quite sure that in almost every instance in which the fistula had existed two months or more proximal dila-

tion of the artery would have been ascertainable if looked for. The size of the involved artery both above and below the fistula should always be compared with that of its fellow. The dilation, as a rule, extends probably to the heart, which also in

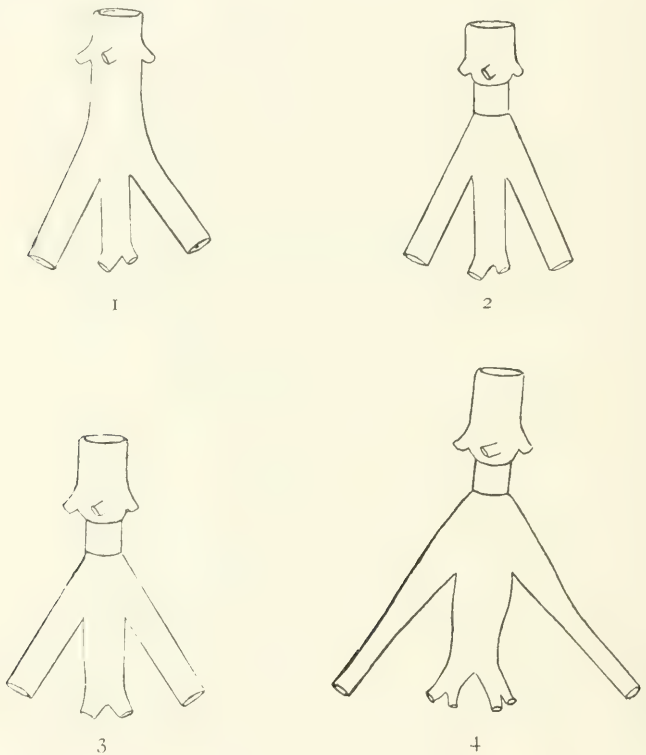

FIG. 8.—Dog 7, series 1. The figures are actual size. 1, aorta before the band was applied; 2, immediately after application of the band; 3, two months thereafter; 4, six months and nineteen days thereafter. (Reproduced from the Journal of Experimental Medicine by the courtesy of the editor.)

my opinion is likely, as I have said, to be dilated. The size of the narrowed artery below the fistula may be difficult to determine without dissection. In view of the observations of Luigi Porta, Dr. Reid and myself it would be well also to bear in mind the possibility of a dilation of any great artery distal to the

site of ligation, and the probability of such dilation if perchance the lumen were in some measure to be reëstablished. As the dilation distal to a totally occluding ligature has been observed only in dogs and only in the aorta and its triad of branches further experimentation is necessary for the determination of the part played by other possible factors, for example, by the anastomotic circulation and by the proximity of the nearest branches —by the length of the dead arterial pocket, in other words.

In a previous paper[1] I made the statement that dilation had not been observed below a totally occluding band (see Fig. 9). Since then, however, a slight degree of dilation, distal to the completely obturated vessel, has taken place in three instances. A dilation of this ventricle-like portion of the aorta between the band and the trifurcation might be expected even in case of complete occlusion, for the anastomosis is very free in this situation and the dead pocket is usually, and perhaps always, too short to become obliterated. Lumbar branches may be given off just below, as they are just above the band.

In two instances I have made the following observation in testing, during the life of the animal, for the patency of the aorta under the band. Pressure with the finger immediately above the band shut off the pulse in what we term the ventricle; whereas, pressure with the back of the scalpel-blade, made as close to the band as possible, did not. In these cases there was a patent lumbar artery so close to the proximal edge of the band that pressure by the finger obliterated it, whereas the knife-blade which could be brought to bear on the aortic wall between this little artery and the upper edge of the band did not interrupt the flow in this important anastomotic branch. The contribution of this little artery to the anastomotic bloodstream was sufficient to convert an inpalpable into a palpable pulse. A palpable pulse in the ventricle below the band is so invariable, whether the aorta has been completely occluded or not, that the patency of the artery under the band cannot be definitely deter-

[1] Halsted and Reid: Loc. cit.

mined during the life of the animal unless temporary occlusion of it between the band and the nearest lumbar artery obliterates or decidedly influences the pulse in the ventricle. If pressure above the band does not affect the pulse just below it we may conclude that obturation is complete.

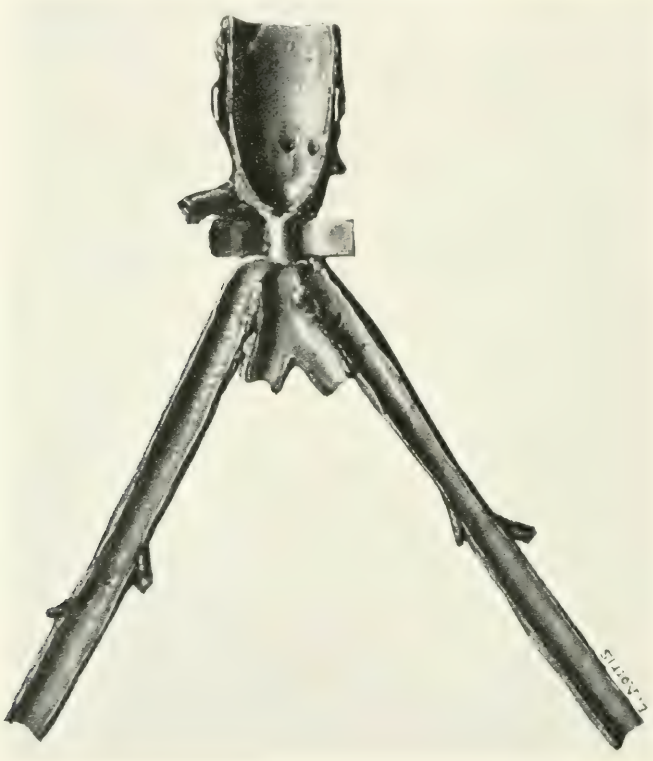

FIG. 9.—Complete occlusion of the aorta of a dog by a metal band. Note the absence of dilation below the band seven months after its application. (Reproduced by the courtesy of the editor of the Journal of Experimental Medicine.)

Fortunately it occurred to me a few days ago to restudy, with reference to the possibility of finding depicted a dilation of an artery below a ligature, the sketches of surgeons who in bygone

years had experimentally ligated the bloodvessels of animals. I was delightfully surprised to find, in the beautifully illustrated volume of Luigi Porta,[1] published in 1845, two drawings which portray a pronounced dilatation of the aorta and its ventricle

FIG. 10.—The aorta of a dog eight months after ligation. Aorta dilated distal to the site of the ligation. (Luigi Porta, loc. cit.)

immediately below the site of ligation (see Figs. 10 and 11). The ligatures in the two dogs had been applied eight and fifteen months before the death of the animals. There is a great bundle

[1] Delle alterazioni patologiche delle arterie per la legatura e la torsione. Milano, 1845, pp. 350, 351, Plate V, Figs. 3 and 5.

of dilated vessels—the vasa vasis—bridging the gap between the retracted ends of the dilated aorta (Fig. 11).

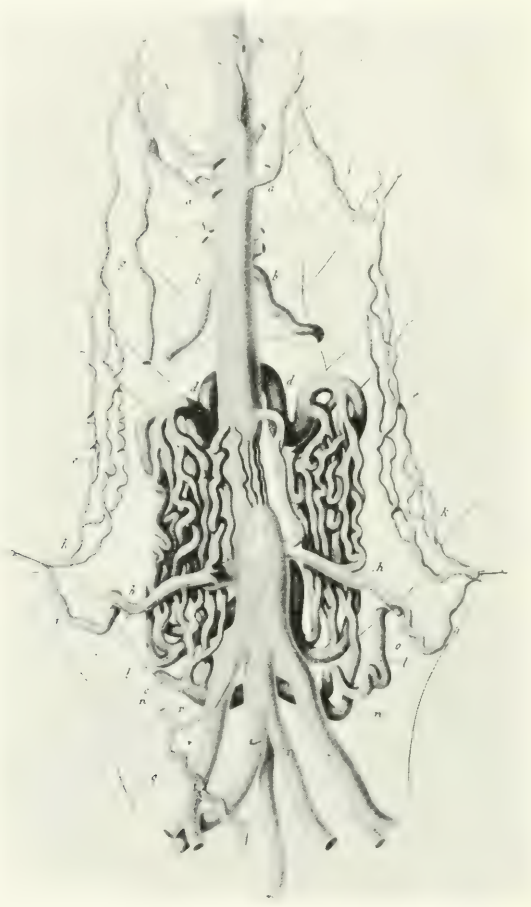

FIG. 11.—The aorta of a dog fifteen months after ligation. Note the distal dilatation and the anastomotic circulation. (Luigi Porta, loc. cit.)

Thus three-quarters of a century ago this great, perhaps the greatest, surgeon of Italy furnished irrefutable proof of a remarkable phenomenon which must eventually have interest for the physiologist, the pathologist and the surgeon. Luigi Porta

describes the drawing but makes no further comment upon the dilation.

Before the introduction of antiseptic surgery by Lister, thrombosis quite invariably followed ligation of an artery, and it was to the organization of the thrombus that the surgeon looked for the prevention of secondary hemorrhage and for the preservation of the life of the patient. If thrombi formed in these two cases of Porta they must have been eventually absorbed, for the distribution of the dilated vasa vasis proves that the aortic free ends were patulous, and we have further proof of this in the dilation of the aortic ventricle immediately below the site of the ligation.

In the course of my experiments in partial occlusion of the arteries I have often studied the illustrations, carefully I thought, in Luigi Porta's work, but not until I scanned them with the particular object in view did I discover the dilatations so strikingly manifest. I wonder if anyone has ever commented upon or been interested in these two observations of Porta.

The following summary is quoted from a paper read at the annual meeting of the National Academy of Sciences in April, of this year.

Summary. 1. A partially occluded artery (abdominal aorta, innominate, carotid, subclavian) may dilate distal to the site of constriction.

2. The dilation is circumscribed and has been greatest when the lumen of the artery (the aorta) was reduced to about one-third or perhaps one-fourth of its original size.

3. When the obturation has been slight in amount dilation has not been observed; of 7 cases of complete obstruction there has been a very moderate degree of dilation in 3 and none in 4.

4. Complete or partial occlusion of the thoracic aorta may be followed by dilation central to the point of constriction.

5. Dilation or aneurysm of the subclavian artery has been observed twenty-seven or more times in cases of cervical rib.

6. The dilation of the subclavian in these cases is circumscribed, is distal to the point of constriction and strikingly resembles the dilation which we have produced experimentally.

7. The dilation of the artery proximal to an arteriovenous fistula and distal to a partially occlusing band may prove to be referable to the same cause.

8. When the lumen of the aorta is considerably constricted the systolic pressure may be permanently so lowered and the diastolic pressure so increased that the pulse pressure may be diminished by one-half.

9. The experimentally produced dilations and the aneurysms of the subclavian artery in cases of cervical rib are probably not due to vasomotor paralysis, trauma or sudden variations in blood-pressure.

10. The abnormal, whirlpool-like play of the blood in the relatively dead pocket just below the site of the constriction and the lowered pulse-pressure may be the chief factors concerned in the production of the dilatation.

11. Bands, rolled ever so tightly, do not rupture the intima.

12. Intimal surfaces brought, however gently, in contact by bands or ligatures do not, in our experience, unite, for the force necessary to occlude the artery is sufficient to cause necrosis of the arterial wall.

13. The death of the arterial wall having been brought about by the pressure of the band, a gradual substitution of the necrotic tissue takes place, the new vessels penetrating it from both ends. It is, I believe, in this manner that an artery becomes occluded, and it is thus that a fibrous cord forms within the constricting band.

DIVERTICULA OF THE BLADDER

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The increasing frequency with which we have encountered diverticula of the bladder in the past few years has led me to review the cases that have been treated at the Mayo Clinic. Presumably this condition does not occur more frequently now than formerly, though with a somewhat better understanding of the surgery of the bladder in general, and with the great advance in methods of examining all patients with bladder trouble, many more are being presented for surgical treatment.

Etiology and Pathology. The question as to whether or not these diverticula, as well as those occurring in other parts of the body, are congenital or acquired, has been widely discussed, and many convincing articles have been published supporting each contention. Undoubtedly diverticula of the bladder may be congenital, as instances have been reported in infants and small children, and it would certainly seem that in most of such cases there must have been some congenital defect in the bladder as a primary etiological factor. If the condition were always due to obstruction it would probably occur more often in cases in which the stream of urine is obstructed. It has been suggested that the weak points in the wall of the bladder may be at the site of one of the embryonic buds. While it seems possible that a diverticulum might occur at one of these points, and that this embryonic weakening might be the factor in certain cases, on the other hand, my observation leads me to believe that the point of dereliction is not constant enough to indicate that the majority originate from these buds. In most of our cases the opening of the diver-

ticulum was not far from one of the ureteral meatuses, but the relationship to the meatus was not at all constant, so that in some cases the diverticulum opened into the bladder in front of the meatus of the ureter, in others, well above it or posterior to it, and in some cases in the base of the bladder posterior to the trigone. It is certain, however, that the greater number of the diverticula do have a proximity to the ureter. The diverticulum that occurs in the dome is rarely seen, and apparently is an entirely different type than the diverticulum under discussion.

The close relationship of the diverticulum to the ureter may mean that the diverticulum, especially if it is of considerable size, will interfere with the ureter. Several cases have been reported in which a hydronephrosis and a pyonephrosis have developed, apparently due to this interference with and pressure on the ureter. Cabot reports an interesting case in which bilateral diverticula were interfering with both ureters. In our series an instance of this kind has not been observed, though in several instances we have been able to demonstrate that the ureteral meatus was just at the border of the opening of the diverticulum, and that in reality the ureter did open into the diverticulum. In one case the ureter emptied into the sac of the diverticulum, and it was necessary to divide the ureter and re-implant it into the new opening in the bladder. In several other cases in which the ureteral opening was marginal the adjoining mucous membrane was turned into the bladder closure, the meatus being preserved. It seems advisable to employ this method whenever it can be done. While a marked trabeculation of the bladder is often seen in cases of diverticula, at the same time it is not at all likely that the trabeculæ will ever become diverticula. Diverticula are true pouches, and in a bladder in which they exist there is always residual urine and other evidence of an incapable bladder. It is because of this that the trabeculæ form, just as they often do in cases in which the inability to empty the bladder is due to the obstructing prostate. When the difficulty is overcome by removing the diverticula the trabeculæ disappear, as in prostate cases when obstruction is removed (Figs. 1 to 6).

FIG. 1.—(179245) Cystogram of a diverticulum from the left base of the bladder. Opening 2 cm. posteriorly and to the left of the left meatus. Resection of the diverticulum.

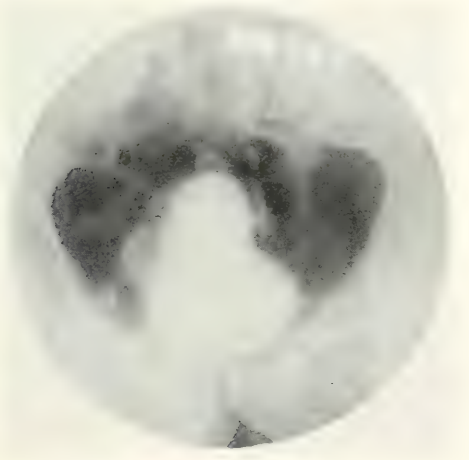

FIG. 2.—(206754) Cystogram of a diverticulum from the right base of the bladder. Opening 2 cm. from the right meatus. Resection of the diverticulum.

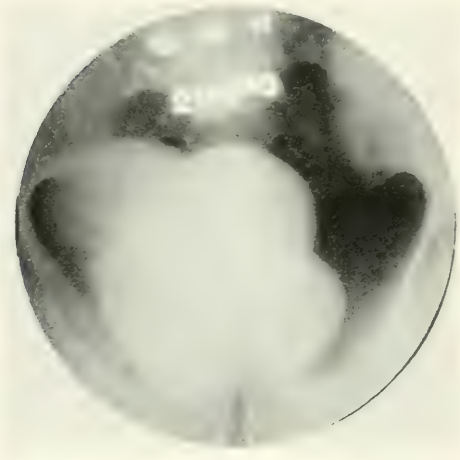

FIG. 3.—(214640) Cystogram of a diverticulum of the right wall of the bladder. Opening about 3 cm. posteriorly and to the right of the right meatus. Resection of the diverticulum.

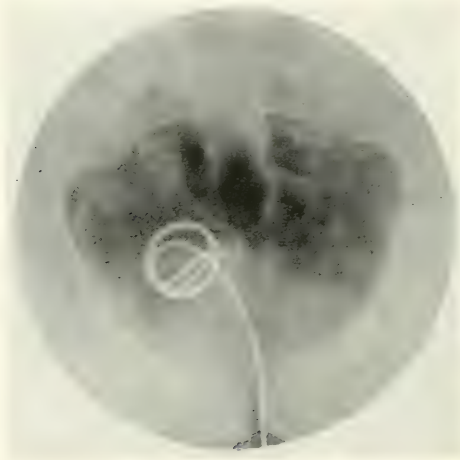

FIG. 4.—(206754) Stylet coiled in the diverticulum from the right base of the bladder. Opening 2 cm. from the right meatus. Resection of diverticulum.

FIG. 5.—(155042) Stylet coiled in the diverticulum of the right base of the bladder. Opening 3 cm. from the right meatus. Resection of the diverticulum.

FIG. 6.—(224370) Stylet coiled in the diverticulum from the left base of the bladder. Opening 2 cm. posterior and to the left of the left meatus. Resection of the diverticulum and prostatectomy.

Classification of Diverticula. Diverticula have been classified as congenital and acquired. The congenital type was formerly thought to be that in which all coats of the wall of the bladder were involved in the diverticulum; the acquired type had a sac composed of mucous membrane only (Figs. 7 to 14). This classification, made by Englisch sometime ago, would not, I think, hold according to most observers at the present time. It seems to be the consensus of opinion that a congenital deformity, or lack of development, is a factor in all of these cases. However, there seems to be two distinct types, one in which the diverticulum is associated with an enlargement of the prostate, and which has led some observers to believe that it is the result of the obstruction from the prostate, and the other type occurring in much younger men in which there is no evidence of obstruction from any cause. The latter patients will frequently have more residual urine than those with an enlarged prostate and a diverticulum. In either of the two types the diverticula may be multiple, though usually there is a large sac and one or more small ones.

Many cases have been cited to show that obstruction is not a factor in the causation of the condition. It has been demonstrated repeatedly that in case there is an obstructing enlargement in the prostate associated with diverticulum of the bladder that the removal of the obstruction will not relieve the situation, and, furthermore, that the removal of the prostate and diverticulum will completely relieve all symptoms. I wish to emphasize this point particularly because I believe that many of the patients with prostatic trouble who continue to have the so-called cystitis and residual urine after the obstruction has been removed are, in reality, suffering from diverticula, and that if a careful examination is made for a diverticulum at the time of the prostatectomy in such cases this error will be avoided. I feel certain that we have overlooked a number of diverticula among the prostatic patients and that many are now receiving irrigations of the bladder and catheterizations under the assumption that the symptoms are produced by cystitis when in reality they are caused by the diverticula.

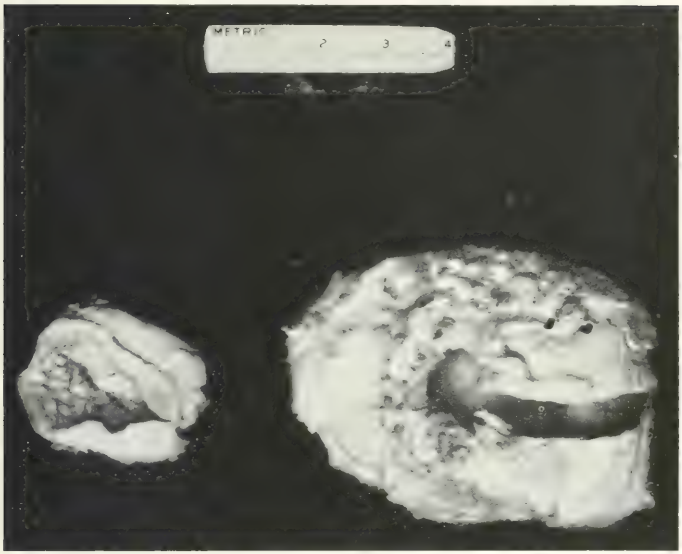

FIG. 7.—(226631) Diverticulum.

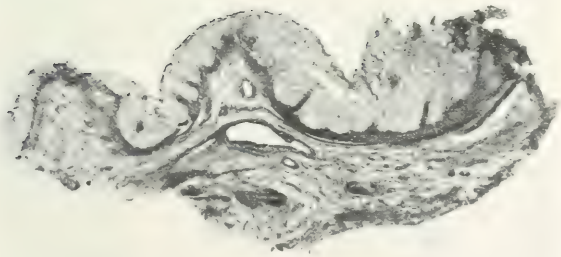

FIG. 8.—Same as Fig. 7. Low power section through the entire thickness of a large diverticulum, showing the mucous membrane.

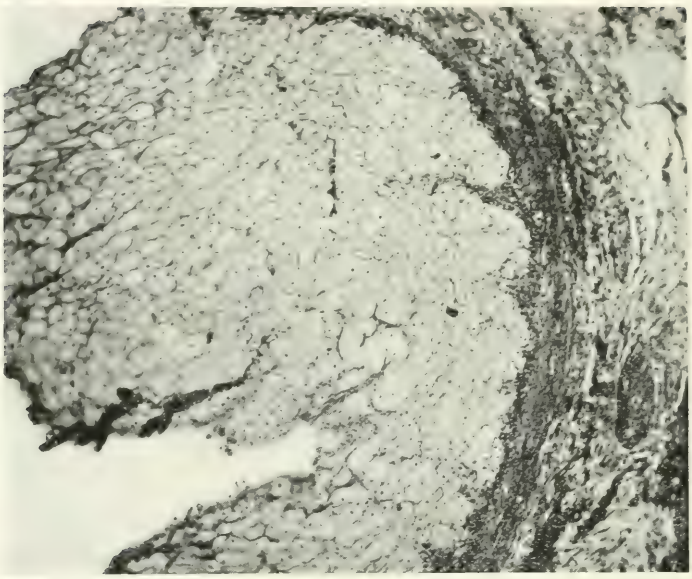

FIG. 9.—Same as Figs. 7 and 8. High power, showing mucous membrane and strand of smooth muscle of a large diverticulum.

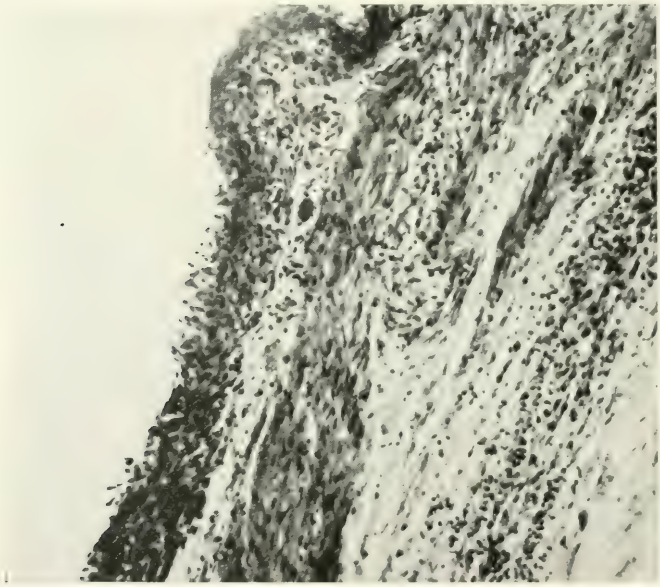

FIG. 10.—Same as Figs. 7, 8 and 9. Different area from Fig. 9. Showing scanty mucous membrane and strands of smooth muscle.

FIG. 11.—(49150) Diverticulum.

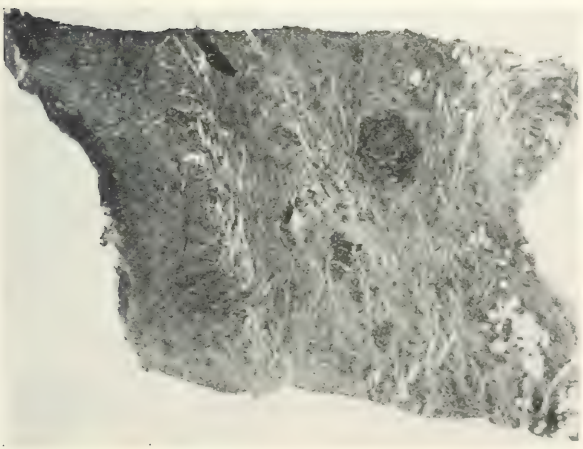

FIG. 12.—Same as Fig. 11. Low power, showing smooth muscle in fat. The mucous membrane is absent.

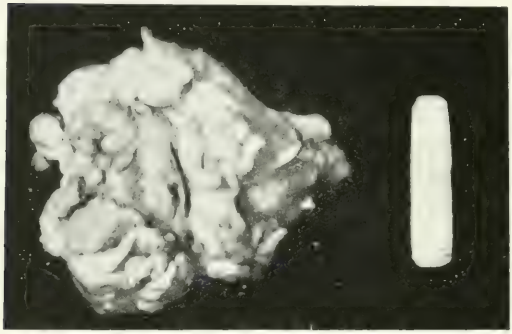

FIG. 13.—(206754) Gross photograph of diverticulum.

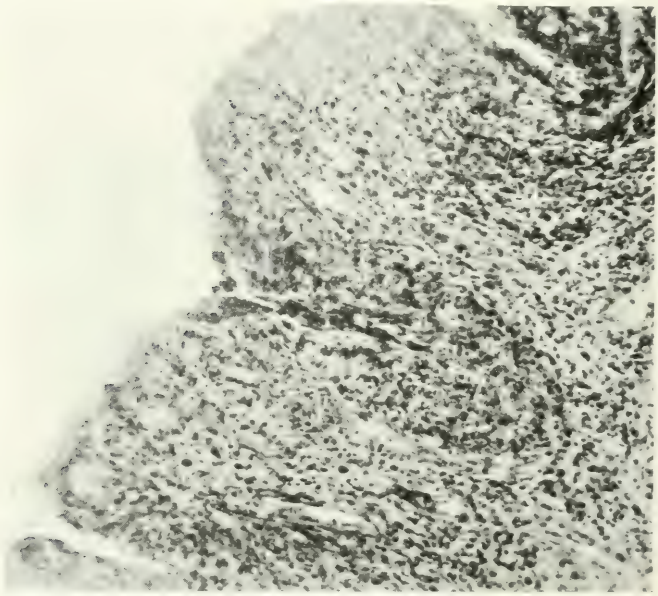

FIG. 14.—Same as Fig. 13. High power, showing diverticulum. Mucous membrane with absence of muscle.

Whether the sac is composed of all the coats of the bladder or whether it is composed of the mucous membrane alone does not seem to draw a line between the etiology of the congenital and acquired types in these cases. There must be some congenital defect which will allow these sacs to develop, though their development may be aided and increased by an obstruction to the urinary outflow. In the young man with this condition the bladder is usually large, but the wall is not particularly thick and may appear quite normal. In the type occurring in older men, especially with prostatic trouble, the wall of the bladder is very thick from hypertrophy. In such cases the sac is adherent and firmly attached to the side of or beneath the thick bladder, and there will frequently be much pericystitis and evidence of old and recent infection without perforation. This usually exists in the cases in which the sac lies between the bladder and the rectum. In young men the sac is thin and is not firmly attached in the surrounding tissues, so that it is readily separated with very little dissection. Stagnation in the dependent sac favors infection, which results in diverticulitis and consequent cystitis. It has been our experience that in the infected case apparently the greatest degree of infection is in the sac, though there is all the evidence of infection in the bladder as well. It is not unusual, in dilating the orifice of the diverticulum, to see thick pus escaping into the bladder, giving the appearance of opening an abscess under tension. Pericystitis and diverticulitis are always present to some degree in the case of the thick-walled sac. Calculi are often found in the sac, as was the case in four of our patients. In one of our cases, previously reported by Martin, a dumb-bell-shaped stone, partly in the bladder and partly in the sac, was found. There was carcinoma in the sac in one of our cases and carcinoma and stone in another.

Clinical Features. Diverticulum of the bladder occurs almost exclusively in the male; very few cases have been reported in the female. The characteristic feature of the clinical syndrome is a feeling that the bladder is not emptying. This comes on almost immediately after voiding, with the ability to repeat the

act of voiding and the second time to pass a considerable amount of urine. Urination may be painful, particularly if the diverticulum is large. The sac may be palpated in some cases, especially through the rectum. Frequency and burning, with difficulty of urination, were present in most of our cases. Such symptoms always occur in cases after infection has taken place. Patients with diverticula have all the features of marked cystitis, and often are treated over long periods for this condition. It is almost a pathognomonic sign of diverticulum to have a considerable amount of urine, thick with pus, escape from the catheter just at the time the bladder was supposed to be entirely clean. The urine in these cases is very foul, and on opening the bladder to perform a prostatectomy or drainage operation, should this foul urine be detected a diverticulum should be suspected and looked for. In the long-standing case, evidence of a kidney infection and insufficient renal function becomes marked. A low percentage of phenolsulphonephthalein return is not a definite contra-indication to surgical treatment in all of these cases; many of the patients do well in spite of this condition.

Diagnosis. While the diagnosis is suggested by the clinical features the accurate determination of the condition rests with the cystoscopic examination and the employment of the leaded catheter and roentgen rays, or by the making of a cystogram which is of great value in any doubtful case. The cystoscope will usually reveal the condition, though in the case of an enlarged prostate, or in very marked cystitis when the mucosa of the bladder is greatly congested and distorted, it may be impossible to see the opening through the cystoscope, and a cystogram should then be made. In other instances the opening of the diverticulum into the bladder is very small and difficult to see, but the colloidal silver solution will readily pass into it and the diverticulum can be seen when the roentgenogram is made. In any very marked case of cystitis in which the bladder is to be drained a diverticulum should be searched for, even if these methods of examination fail to show one, as it is possible that the opening might be closed and the diverticulum not recognized at the time

of the examination. In view of the fact that I have had a great deal of difficulty in making a diagnosis in some of these cases, particularly in those in which there was an obstructing enlargement of the prostate, it seems well to emphasize the necessity of a careful exploration of the bladder at the time of performing the prostatectomy in cases showing marked cystitis and infection at the time of the examination. A diverticulum should be suspected in the patient who has had a prostatectomy and still has a considerable amount of residual urine, particularly if there is much evidence of infection which does not respond to the ordinary treatment.

This report is based on a group of 44 patients operated on between February, 1908, and March, 1918. All of the patients were males, varying in age from eighteen to seventy-three years. Twelve gave a history of gonorrheal infection, and 3 of the 12 had been treated for strictures of the urethra. There is no evidence to show that the infections or strictures were in any way responsible for or had anything whatever to do with the formation of the diverticula. Six of the 44 patients had been operated on previously for these symptoms, without relief. Eight of the patients gave a history of some form of trauma, which might have been a factor to consider in the etiology, but the association was too remote to prove that the trauma had anything to do with the weakening of the wall of the bladder or had in any way been a cause of the diverticula. We believe the trauma was merely incidental. Seventeen of the patients also had an enlargement of the prostate and the remaining 31 had cystitis, graded at least 3 on a scale of 4. There was stone in the bladder in 6 of the patients and carcinoma in 4; in 1 the carcinoma originated within the diverticulum. At operation the opening of the diverticulum was found in the floor of the bladder or on one or the other of the lateral walls not far from the ureteral opening in 39 of the 44 patients, which shows that a large percentage of such diverticula originate in one of these regions. The greatest number, 19, were found near the base of the bladder on the right wall. Bladder trabeculation, 3 on a scale of 4, was noted in 38 of the 44 patients.

Treatment. In reviewing the literature and from our own records it stands out clearly that palliative treatment and any other form of treatment other than excision of the diverticular sac have not given good results. A mortality as high as 83.1 per cent. has been reported in cases in which there was a diverticulitis at the time of the operation. This percentage has been very greatly

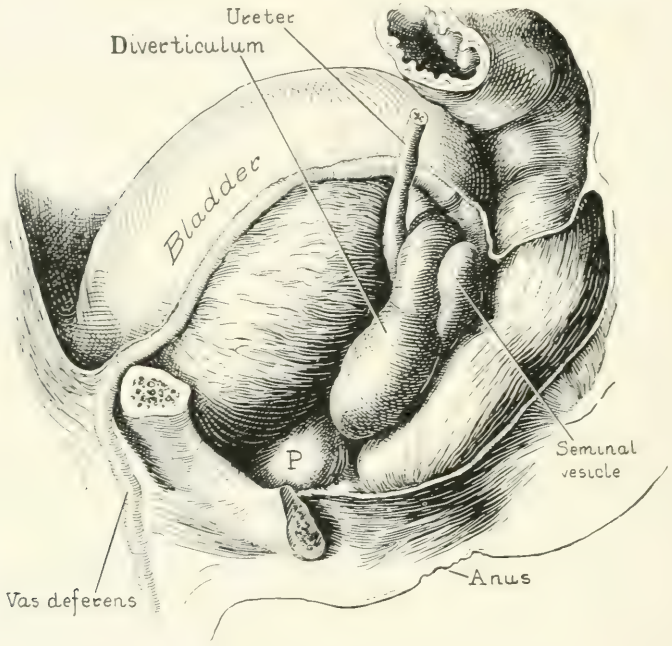

Fig. 15.—Diagrammatic sketch, showing the relation of the diverticulum to the bladder, prostate, rectum, seminal vesicle and ureter.

reduced. In the young man without infection the results are uniformly good, though complete recovery may be slow. In some of our cases the wound was slow in healing and in others several ounces of residual urine persisted for a number of weeks though eventually it almost entirely cleared up. Something can be accomplished by preliminary washings of the bladder and by employing methods to stimulate renal function in cases in which it seems necessary. Those who have had the most experience with

these cases seem to be unanimous in the feeling that the proper treatment for any of these diverticula is complete excision of the sac, and that any treatment less radical will not be satisfactory. Our experience bears this out. Intravesical treatment, as can be readily seen, is of no avail except as a palliative when operation is contra-indicated or preliminary to operation. Drainage of the

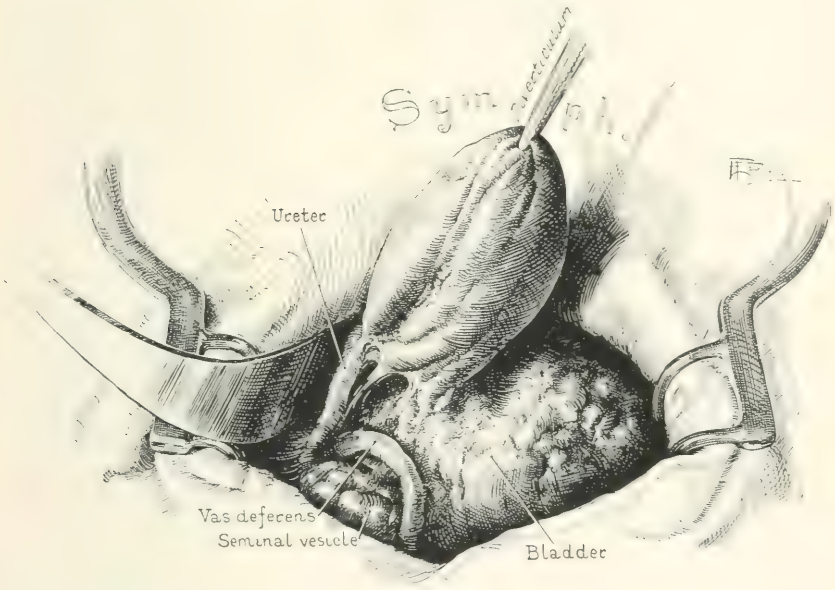

FIG. 16.—(215976) Relation of the neck of the diverticulum to the ureter and vas deferens, after the sac of the diverticulum has been dissected out from beneath the bladder.

bladder, even as a preliminary step, will seldom help enough to warrant its being done. We have drained a number of times in these cases, both at the time of the prostatectomy and when the diverticulum was the only lesion. I now believe that it is far better under ordinary circumstances, to remove the diverticulum at the same time. Suprapubic drainage of the bladder, even when the drainage tube extends into the diverticulum and is left there for a long time, will not help permanently. So far as I am aware the

less radical operations, such as enlarging the opening of the diverticulum and doing a plastic operation on the opening, and of anastomosing the diverticulum to the bladder, are not satis-

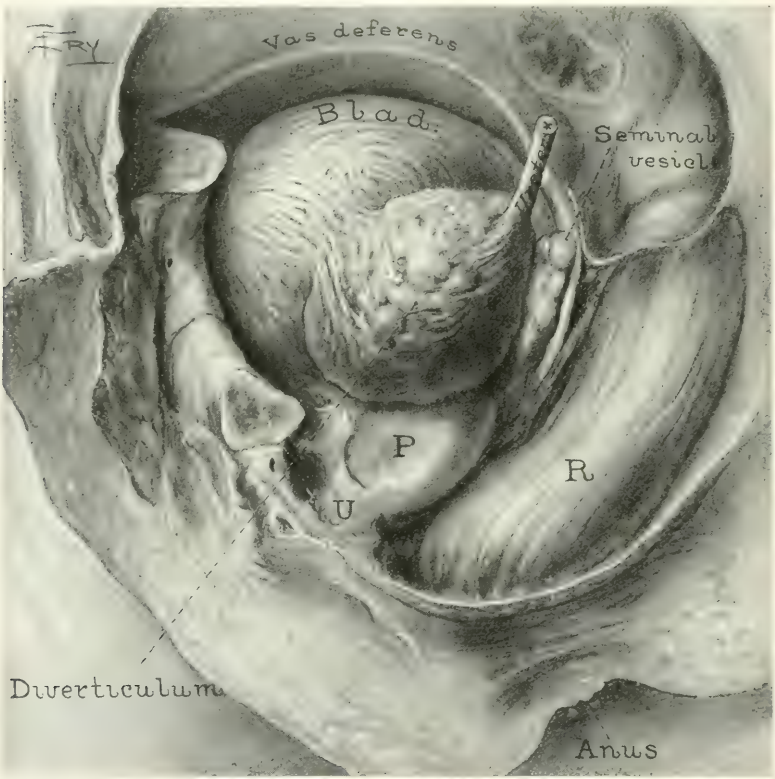

FIG. 17.—(215976) The situation of the diverticular sac on the left posterolateral wall and at the base of the bladder. The ureter enters the sac instead of the bladder. The cavity of the sac is approximately half the size of the bladder cavity.

factory. Therefore the treatment resolves itself into the excision of the diverticulum as soon as the patient's general and local conditions have been improved as much as possible.

The operation consists in first making a fairly good-sized opening into the bladder through the prevesical space and locating the opening of the diverticulum, after all the pus and infected mucus has been cleared away. The prevesical tissue should be protected against infection in every way possible. Ingenious methods have been devised for filling the diverticulum with an air-filled rubber

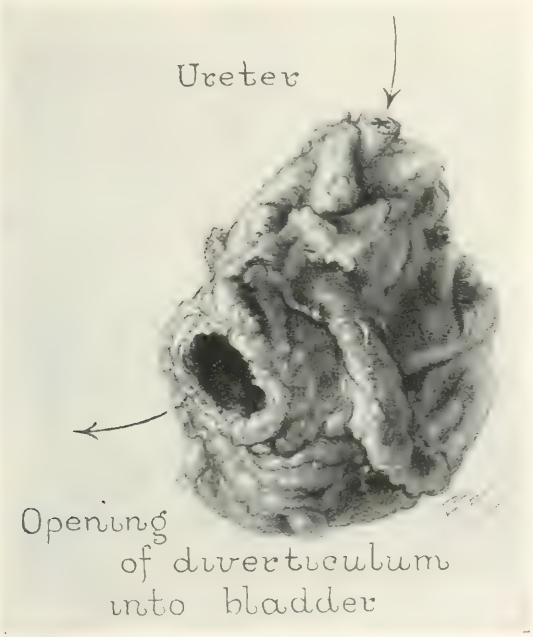

FIG. 18.—Diverticular sac and its opening, which communicates with the bladder. Note the ureter entering the sac.

bag (Lerche) and also for filling the sac with gauze (Lower), which is packed into the sac beforehand, to facilitate its removal. Such devices seem to help considerably. Whenever possible I prefer to pass one or two fingers into the diverticulum and then make the dissection through the prevesical tissues down onto the sac, which is also being lifted out by the fingers within it. This method

is not new; it can be employed in almost all cases, and is specially helpful when the sac is firmly attached to the surrounding tissues. If the sac lies high up and is covered by peritoneum it may be best to open the peritoneum, though, as a rule, this is not necessary. After the sac has been completely freed from the surrounding fatty tissue the neck is severed, the opening in the bladder is

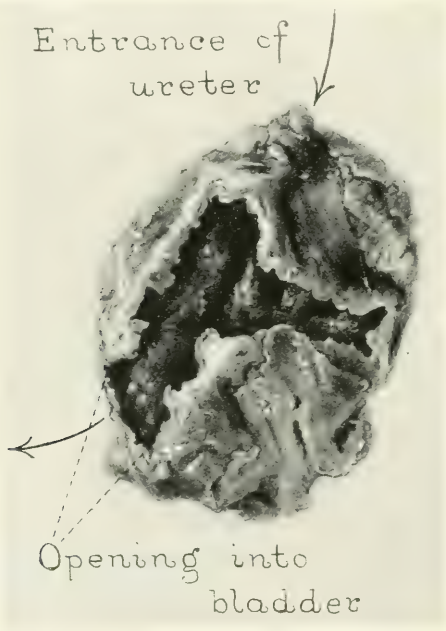

FIG. 19.—(215976) The diverticulum after it has been cut in half. Note the communication opening into the bladder and the entrance of the ureter into the diverticulum.

closed and a drain is placed in the prevesical space which the sac occupied. The suprapubic opening in the bladder is closed, with the exception of the place for the drainage tube. The difficulties of the operation lie in separating the sac from the surrounding tissue, particularly if the sac is thick-walled and if there is a great deal of old infection and scar tissue. The vas deferens and the

ureter, both of which will come into view in many of the dissections, should always be avoided (Figs. 15 and 16). Occasionally it will be necessary to divide the ureter and to re-implant it in a new area in the bladder, as I did in one of our cases (Figs. 17–19, Case 215,976). If there is an enlargement in the prostate it should be removed at the same time (Figs. 20 and 21).

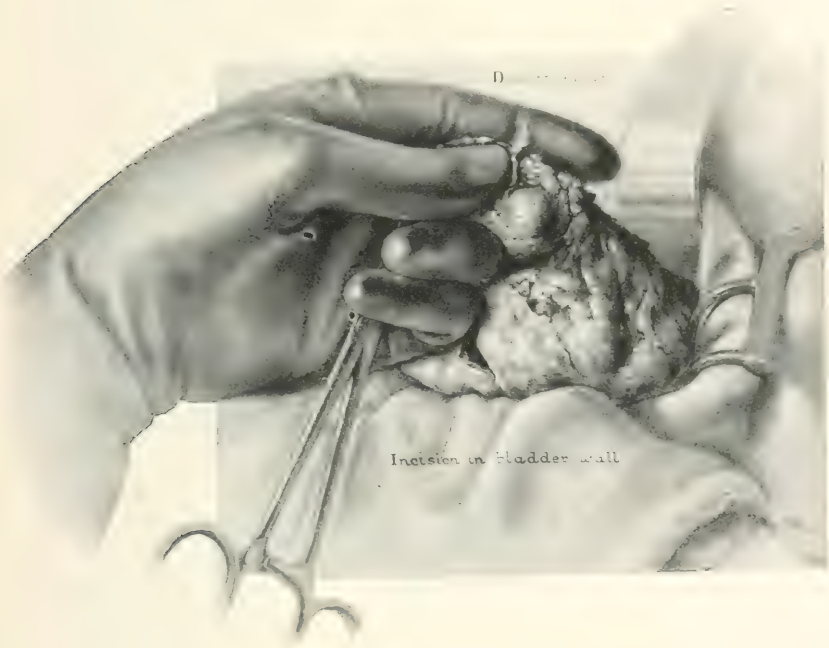

FIG. 20.—Finger passing through the incision in the dome of the bladder into the neck and cavity of diverticulum. The diverticulum being lifted out of the surrounding prevesical tissues.

In this series of 44 patients, so far as we have been able to determine, all but 10 are living. Two of the patients died within a few days after a drainage operation; both of these men had septic kidneys and drainage was of no avail. The other deaths occurred after the patients had been up and around for some time, and in most instances after they had gone home. The general and

functional results in the remaining 34 patients have been uniformly good. The functional result, in so far as emptying the bladder is concerned, may be slow to adjust itself, though eventually it will be practically perfect.

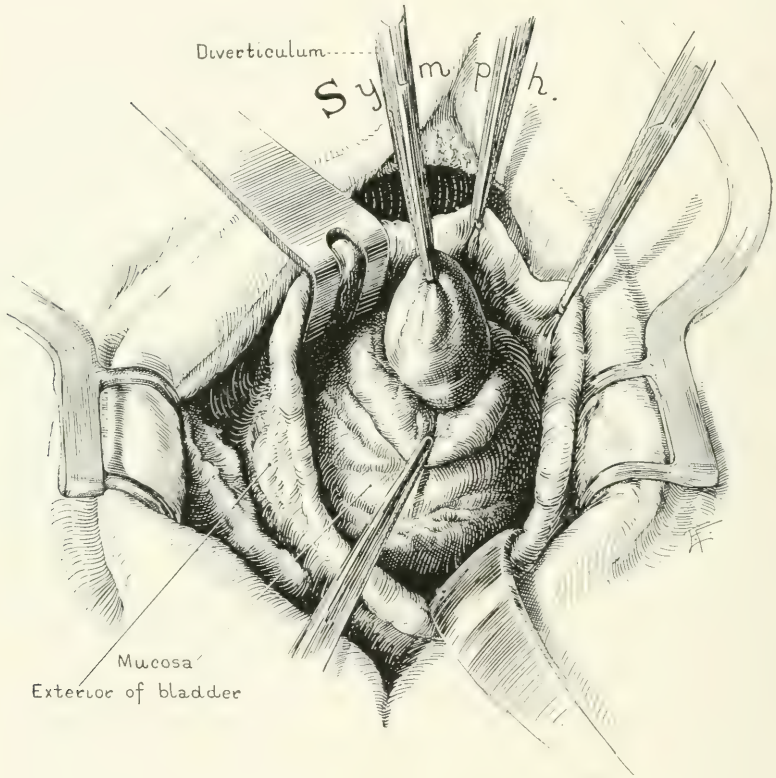

FIG. 21.—Transvesical operation for diverticulum of the bladder. The diverticulum is not adherent, and is tracted into the bladder by hemostats.

Summarizing, briefly, it may be said, that diverticulum of the bladder is much more common than has been realized and that the condition is perfectly amenable to surgical treatment.

FORTY-FOUR PATIENTS OPERATED ON FROM FEBRUARY, 1918, TO MARCH, 1918

Youngest	18 years
Oldest	73 "
Average age	52 "

	Cases
History of venereal infection	12
Urethral stricture in 3 (sound passed in 1, stricture cut in 2)	
Previous operation on the bladder (elsewhere)	5
Previous perineal prostatectomy (here)	1
Symptoms dating from previous trauma	8
Enuresis since childhood	2

First Symptoms Noted

Hematuria	8
Difficulty in urinating	15
Frequency	21

Symptoms

Repeated urination	5
Hematuria	14
Pyuria	17
Burning on urination	26
Frequency	35
Difficulty in urinating (catheter used in 9)	24
Loss of weight noted	18
Average loss of weight (pounds)	15
Cystoscopic examination in	35
Hypertrophied prostate found in	17
Cystitis (average 3)	31
Bladder stone	6
Stone and carcinoma	2
Carcinoma (carcinoma in diverticulum in 1)	2
Cystoscopic localization of the diverticulum	35
Dome of bladder	3
Left wall and base	11
Right wall and base	12
Base	3
Multiple diverticula of base	6

Urinalysis

	Cases.
Pyuria	25
Hematuria and pyuria	17
Location of the diverticulum at operation	45
Right wall and base (10 near right ureter)	19
Left wall and base (6 near left ureter)	11
Left ureter in diverticulum	1
Floor and base	11
Dome	3
Bladder trabeculation (average 3)	38
Bladder stones	7
Carcinoma	3
Carcinoma and stone	2
Hypertrophy of the prostate	18
Stones in the diverticulum	4
Carcinoma in the diverticulum	1
Carcinoma and stones in the diverticulum	1

Type of Operation

Intraperitoneal resection of the diverticulum	2
Extraperitoneal resection of the diverticulum	16
Exptraperitoneal resection of the diverticulum and prostatectomy	7
Exptraperitoneal resection of the diverticulum, prostatectomy and removal of stones	1
Extraperitoneal resection of the bladder for cancer, prostatectomy and resection of the diverticulum	1
Extraperitoneal resection of the diverticulum and transplantation of the ureter	1
Drainage of the bladder and prostatectomy	5
Drainage of the bladder and removal of stones	6
Enlarging the opening of the diverticulum and drainage of the bladder	4
Separation of septum between bladder and urethra	1

Deaths Reported in Forty-four Cases, 10

Type of operation.	Length of life.	Cause of death
Drainage of bladder	2 days	Pyelonephritis
Drainage of bladder	4 days	Acute septic nephritis
Drainage of bladder and prostatectomy	25 days	Bilateral pneumonia
Extraperitoneal resection of diverticulum	28 days	Pulmonary embolus
Extraperitoneal resection of diverticulum	1 month	Pyelonephritis
Drainage of the bladder	2 months	Pyelonephritis
Drainage of bladder and removal of stone (carcinoma in the diverticulum)	2½ months	Pyelonephritis and perivesical abscesses
Enlargement of opening in diverticulum	9 months	Not known
Extraperitoneal resection of the diverticulum containing carcinoma	12 months	Not known
Drainage of the bladder	36 months	Not known

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ENLARGED THYROID PRODUCING SUFFOCATION BY DISPLACEMENT BENEATH THE STERNUM

By H. BEECKMAN DELATOUR, M.D.
BROOKLYN, N. Y.

The two cases herewith reported seem to be unique. We have failed to find any reference in literature to any similar condition. That a cervical thyroid might become displaced and result in death seems hardly possible, but in one of the cases here reported that did occur.

Case I.—Wife of a physician, aged twenty-four years, for several years was known to have an enlarged thyroid and with it many of the regular nervous symptoms. One evening, in 1905, while at dinner, she choked and her husband noticed that she was cyanosed and was making strenuous efforts at breathing. On approaching he noticed a change in the contour of the neck; where there had been an enlargement, there was now a depression. Immediately grasping the situation, he placed the patient prone with the head down and hip elevated, and made forcible pressure over the chest. There was an almost immediate slipping of the tumor back to its normal position, with complete relief of symptoms. The patient has remained well since that time and has never consented to operation.

Case II.—A woman, aged thirty-eight years, Russian, had suffered from the presence of an enlarged left thyroid for six years. She had been advised to be operated but refused.

On the evening of May 10, 1917, she was seized with dyspnea and pain in the region of the sternum, following an attack of coughing. Dr. L. B. Cohen was called to see her an half hour

later and found her cyanosed, breathing with great difficulty and the pulse very rapid and feeble. I was called in consultation and arrived about half an hour later but found the patient had died about fifteen minutes before my arrival, this being about forty-five minutes from the onset of the attack.

Examination revealed a marked cyanosis of the face and neck and of the entire left upper extremity. The left side of the neck was flattened, the tumor which had been present for six years had disappeared and the upper edge of it could be felt just behind the clavicle and sternum.

Although strongly urged the Coroner would not order an autopsy.

These cases seem similar in all respects. In the first life was evidently saved by the husband being immediately at hand and correctly diagnosing the condition.

It is quite evident that the enlarged gland, in one case by choking, and in the other by coughing, was drawn down from its place in the neck behind the unyielding sternum and clavicle, and there pressed upon the trachea and important bloodvessels. In the second case it was evident that the return circulation from the left upper extremity had been completely shut off.

Why and how this condition can be produced it is impossible to say.

The dangers of such an accident should be borne in mind and probably no better procedure could be adopted than that which was used in the first case mentioned.

It is not very uncommon to find an enlarged thyroid gland extending beneath the sternum and producing marked symptoms. In both these cases the thyroid was entirely in the neck until during violent exertion it became dislocated beneath or behind the sternum.

FISTULA OF THE COLON

By C. H. MAYO, M.D.
ROCHESTER, MINN.

Although fistulas of the colon fortunately occur but rarely, their occurrence is too frequent for the credit of the surgeon and the comfort of the patient. They are, however, apparently more common than they really are, because they are often considered as new cases in various clinics. Patients who are so unfortunate as to have fistulas, usually show the scars of numerous operations for their repair.

Practically all cases of fistula of the colon arise from infection, for the relief of which surgery is indicated; but few are caused by external trauma. Occasionally they result from injury of the intestine caused by the separation of adhesions, the surgeon overlooking a small perforation, or, the fistula is a sequel to an operation for the relief of obstruction. However, in these cases, if the bulk of the intestinal discharges is delivered normally, and if the opening is not absolutely necessary for relief or for the preservation of life, patients will readily undergo prolonged treatment or repeated operation for cure in preference to the fistula. Most of them are greatly distressed by the condition, and even a necessary colostomy is accepted only because it relieves the intense or prolonged suffering. The abdominal wall is very rarely perforated by infection. Such a condition, however, accounts for a small percentage of the cases in which fistulas occur in the lower abdomen, secondary to diverticulitis. In a few such cases perforation into the bladder takes place, while more rarely a fistula dissects its way along the rectum to the ischiorectal fossa.

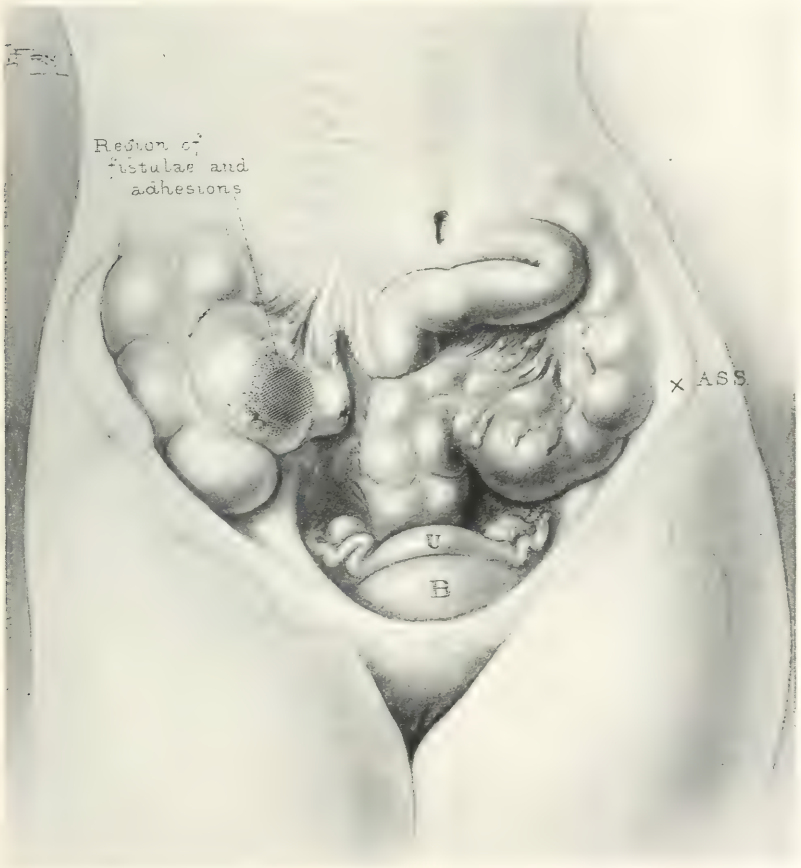
for external discharge. Patients with the latter trouble are seldom cured, yet following repeated operation on the anal canal, they are sooner or later affected by permanent incontinence, in the presence of which the primary condition is unimportant, and really improves with the disappearance of the tension within the bowel. Curiously enough, these small abscesses perforating into the bladder, seldom cause much pain, and I have seen a few patients who complained of the passing of gas with the urine as the first symptom. The true diverticula are very tortuous and the point of perforation is not larger than a small knitting needle. I have not known these conditions to follow an acquired form of diverticulum. The patient's story is often considered incredulous, and it is believed to be impossible that such a condition should exist without the urine passing back into the rectum. The cystoscopist examiner often fails in his first examination. There being no back flow in the diverticulum, the use of methylene blue solutions in the bladder and the testing of the rectal contents are of no aid.

Through an abdominal incision it is easy to separate the fistula from the bladder and successfully to close it on the bladder side, but on the bowel side it must be dissected out of the wall of the intestine or there is danger of recurrence of trouble, not necessarily a fistula. In some cases the local disease of the sigmoid is so extensive that a resection of several inches of bowel is necessary. This is safely done as the three-stage Mikulicz operation, which, unfortunately, requires a considerably longer hospital attention than does the resection by suture, or the tube resection, in which the union is made over a large tube passed through the rectum and out of the anus. In cases of perforating diverticulitis, obstruction, a common symptom of the usual form of the disease, is not present. Years ago, when appendicitis was operated on in the acute stage in the majority of cases, cecal fistulas were common. None of the fistulas or colostomies are more difficult to care for than the wet cecal fistula. The change of bacteria flora from ileum to colon makes a great difference in the intestinal discharges. The practically odorless contents of the lower ileum

is noted following the Brown ileostomy within six inches of the cecum and is in marked contrast to the contents noted in the cecostomy. After the occurrence of a cecal fistula, the surgeon who does the primary operation for its closure should accomplish it through an ample abdominal incision on the inside of the fistulous opening.

Operation. Adhesions are separated, complications dealt with and the opening closed, but if the operation is the fourth or the sixth, and there is no obstructive symptom associated with the nuisance of the fistula, the simplest procedure, in order to avoid again dealing with the adhesions and poor intestinal areas for suturing, is to divide the ileum moderately close to the ileocecal valve, invaginating the lower end and making an end-to-side anastomosis of the proximal end with the sigmoid (see illustration). In some instances this can be done with the transverse colon instead of the sigmoid. This immediately dries the fistula, and only occasionally is it necessary to add a few stitches after separating the mucous membrane from the skin to secure closure of the fistula. The operation is quickly done and is exceedingly satisfactory. Very rarely after these operations is there reverse peristalsis, causing an accumulation of fecal material in the cecum and ascending colon. In such cases Ochsner's permanent mucous drainage is most effective. The colon is divided several inches proximal to the anastomosis, the lower end is closed and the upper end brought into the incision, reducing the size of its lumen around a small tube and leaving the mucous surface without invagination. The stump of the distal ileum is also brought into the wound so that the functionless large bowel may be emptied of its contents by irrigating through this; one fistula only remains and discharges but a little mucus each day. In a few instances in which I have been compelled, as a first consideration, to conserve the strength of the patient, I have found the method most satisfactory. There is no question but that many fistulas heal without operation, the types being those in which the fistulous opening comes close to the parietal peritoneum without an intervening cavity, and this is true whether the fistula is in the vagina

or through the abdominal wall. Injections of various pastes into these latter to aid in the healing is an unnecessary procedure, and in those with internal pockets such treatment is usually a waste of time except as a means of diagnosis with the *x*-ray, as they indicate whether or not a pocket is present.



Practical observations and many years of surgery show that most methods of closure or suture of the small intestine will hold, as it is easier to suture water-tight than gas-tight. A different bacterial flora is found here from that in the large intestine,

and the patient, if need be, will die of obstruction or toxemia before the suturing will give way; but the large bowel must be both gas- and water-tight. The most essential point in these operations for fistula of the sigmoid is to provide for a gas vent, which is obtained by placing a tube with a quarter of an inch lumen in the rectum; the tube may be larger or smaller, according to the case. The abdomen being open, the tube is passed into the bowel through the fistula from above before closing. The side of the tube is sutured to the fistula, allowing its end to extend two inches higher within the intestine; one or two extra openings are made in the tube. Slight traction on the tube from the anal exit helps in the application of purse-string or other forms of sutures to close the fistula. Larger tubes become quite painful as they pass through the anal ring. To relieve this condition and to insure an absence of gas tension, the sphincter ani may be split anteriorly with an electric or Paquelin cautery at the close of the operation. In the case of a vaginal fecal fistula, splitting the sphincter ani in this manner renders a tube unnecessary. This being done with the cautery, there is no infection, and granulation tissues soon protect the area. Vaseline is freely applied, and the contraction of the burn usually closes the muscles to perfect function. When the intestinal wall is much infiltrated around the area of the fistula, an appendicostomy, with a catheter inserted, has often been of great aid in delivering gases from the proximal side. After the second day, a small injection of water through this tube a couple of times a day is of advantage. Should a slight gas fistula be noted on the fifth day, the tube has probably been allowed to accumulate fecal matter. In cases of primary and unexpected fistulas which are passing gases and liquid feces, if the nurse will see that the rectum is kept emptied a considerable percentage of such fistulas will close without other operation. The dry, hard material accumulates and cakes in the rectum and will not be found without digital examination.

LAMINECTOMY AND REGIONAL ANESTHESIA

By CHARLES H. FRAZIER, M.D.
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Occasion arises in the performance of a laminectomy, as it does in other operations, when the attending risk of the procedure may be materially affected by the employment of ether narcosis. Under such circumstances I have sought for methods of conducting the operation without ether and have attempted to apply to the spinal operation methods of anesthesia induced by novocain that are applicable to other fields.

Of the clinical type to which I refer as demanding the use of every safety measure and the elimination of every risk, I may cite, by way of illustration, the case of a woman upward of sixty years of age who had been invalided for a number of years. Her weight was excessive, there had been evidence of cardiac decompensation and the phthalein test of renal function was alarmingly low. Altogether the patient's condition was not such as to warrant any large surgical undertaking without real apprehension, but as her life was rendered miserable by the spinal lesion from which she suffered, operation seemed urgent. Wishing to throw about her every safeguard I decided to eliminate the influence of ether narcosis as a potential source of pneumonia or cardiac decompensation and carried out the operation, a laminectomy of the lower thoracic region, under novocain. In the course of the operation, which lasted an hour and a half, largely for its psychic influence, the anesthetizer was instructed to give inhalations of ether. At all times the patient was conscious enough to answer when spoken to and at the conclusion of the operation the pulse rate was 72.

While regional anesthesia alone is mentioned in the title of this paper, it is desirable that one should be prepared to fall back upon certain supplemental measures, such, for example, as infiltration anesthesia, nitrous-oxide anesthesia and later on the stovaine block. To these we will subsequently refer.

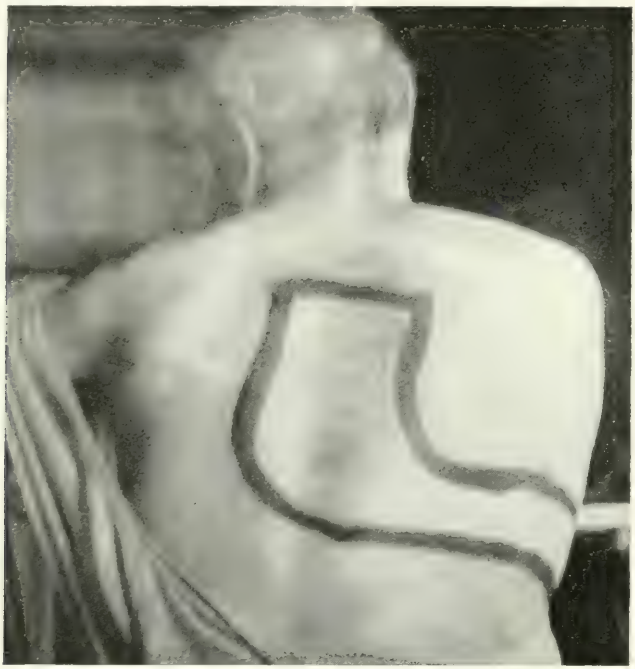

FIG. 1.—Territorial distribution of the cutaneous rami from the posterior primary divisions of the spinal nerves (posterior view). From the effect of trauma or over-stretching, perhaps division in the course of laminectomy, the function of these nerves has been abolished, so that there is an area of anesthesia 4 or 5 cm. on either side of the spinal column. This is the anesthesia which should be procured by the injection of the intercostal nerves according to the technic of regional anesthesia.

In outlining a zone of anesthesia that followed a laminectomy and the division of four posterior spinal roots on the right side for the relief of pain, I observed a band of anesthesia of the left side of the median line of the back. This band corresponded in

length to the number of laminæ that had been removed and was about 5 cm. wide (Fig. 1). The thought at once occurred to me that in the performance of the laminectomy I had destroyed the sensory innervation of the structures invaded in this operation and that if the nerve supply could be reached with the needle, a means was at hand whereby the principles of regional anesthesia might be applied to this territory. From anatomical reference works I found the nerve supply of the structures under consideration to be as follows: After its exit from the intervertebral foramen the spinal nerve divides into two main branches, the anterior and posterior divisions. The posterior primary divisions of the spinal nerves arise either as a single cord from the trunk formed by the union of the two roots or as two separate strands from the roots themselves. They turn dorsally almost immediately and divide into an internal (r. medialis) and an external (r. lateralis) branch which supply the dorsal muscles and integument. Down to and including the sixth thoracic nerve the internal branches are mainly cutaneous and the external entirely muscular. From the seventh thoracic down the reverse condition maintains (Piersol).

As the latter branches, the *rami posterius laterius et medialis*, supply the structures that are invaded in a laminectomy, the question arose as to whether it was feasible to inject these branches with reasonable accuracy. For various anatomical reasons it became evident that a more practical solution of the problem was the injection of the parent trunks. On an earlier occasion my interest in the technic of injecting the intercostal nerves had been aroused in connection with the treatment of severe and intractable forms of intercostal neuralgia with alcoholic injections. I had directed Dr. W. A. Sawyer, at the time a member of my staff, in an anatomical investigation on the feasibility of the injection of the intercostal nerves. The method which he elaborated is that which I have adopted.

To put this method into practice one must be familiar with certain anatomical relationships. To orientate the intervertebral foramen the mid-point between the transverse processes serves

as the guide. The interval between the transverse processes has been estimated as 2.9 cm. to the right or left of the median line. The location of the intertransverse spaces must be determined in the thoracic region by palpation, although in the lumbar region the tip of the spinous process is a little above the lower

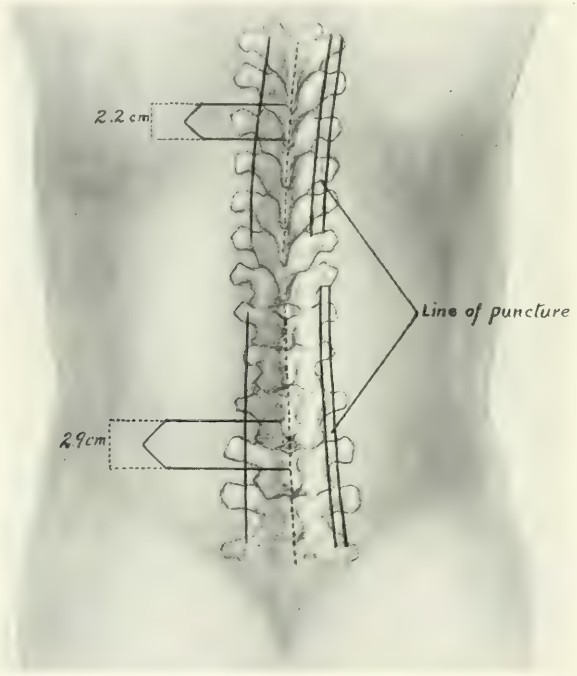

FIG. 2.—This schematic sketch of the thoracic and lumbar spines indicates the distance between the transverse processes in these two regions. The vertical lines 2.9 cm. from the midline. The distance between the midpoint of the spaces between the transverse processes in the thoracic region is 2.2 cm. and in the lumbar 2.9 cm.

border of the transverse process of the corresponding vertebra. But in the thoracic region, having determined the location of one intertransverse space, the location of those above or below is not difficult, since the distance between them is represented as 2.5 cm. and is fairly uniform. With regard to the depth to which the

needle be inserted, the intervertebral foramen should be reached at a distance of 3 cm. in the upper thoracic and 4 cm. in the lower thoracic and lumbar regions. These measurements coincide with those published by Allen (Figs. 2 and 3).

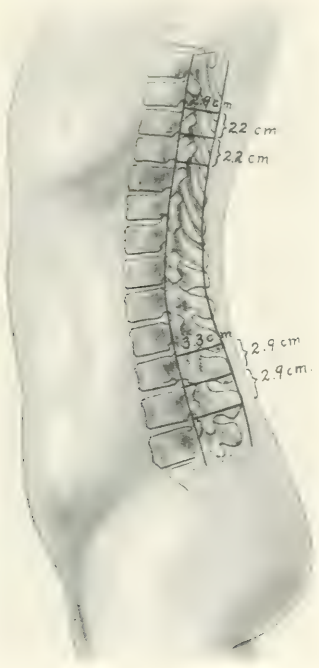

FIG. 3.—Lateral view of the vertebral column to show the distance from the spinous processes to the intervertebral foramina and the distances between the intervertebral foramina in the thoracic and lumbar region. (After Allen.)

A matter of real import in the technic of injection is the direction in which the needle must be inserted. If the needle be inserted at an angle with the transverse midline of less than 45 degrees, the needle may pass through the intervertebral foramen possibly into the cord substance. On the other hand, if the needle be directed at an angle precisely of 45 degrees or a little less the danger is averted. As an additional guide, Sawyer found that the

needle should be directed at an angle of 35 degrees to the cutaneous surface. To determine these angles, measurements may be made with the aid of a protractor.

Preliminary to the operation morphin sulphate gr. $\frac{1}{6}$ and scopolamin gr. $\frac{1}{200}$ are given hypodermically, and if necessary

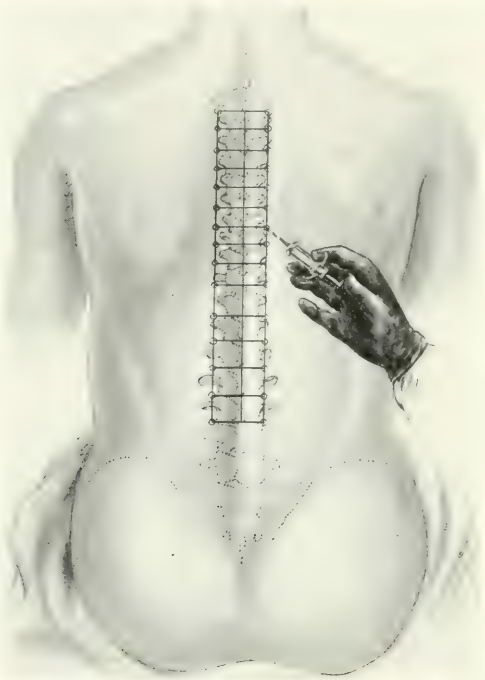

FIG. 4.—A schematic sketch of the spine to show the points of injection of the spinal nerves for regional anesthesia. The vertical lines are 2.9 cm. from the median line; the transverse lines pass through the spaces between the transverse processes.

$\frac{1}{8}$ gr. morphin may be given during the operation. With the patient in position a vertical line is drawn corresponding to the line of the spinous processes. Parallel to this median line are drawn two vertical lines 2.9 cm. to either side, and at a point corresponding to the space between the transverse processes a transverse line is projected at right angles to the midline.

The intersection of the transverse and lateral vertical lines marks the points at which the needle is introduced. After the location of the first intertransverse space has been identified by the successful injection of one nerve, as many more transverse lines are projected as there are nerves to be injected at a distance of 2.5 cm. above or below the first point of injection. Here again

FIG. 5.—Points of injection of the intercostal nerves. Compare with Figs. 2 and 4.

the intersection of transverse and vertical lines marks the point of successive injection (Figs. 4 and 5).

With these topographical landmarks the surgeon proceeds with the injection, provided with a solution of 0.5 novocain, a hypodermic needle, one platinum needle, a Record syringe, a centimeter scale and protractor. The skin and subcutaneous tissues are infiltrated with the novocain solution and the platinum

needle is then introduced at the proper angle, that is, at an angle of 45 degrees or a little less to the transverse line and of 35 degrees with the cutaneous surface. The distance to which the needle must be advanced will vary according to whether the individual be lean or stout. On the average the distance to the nerve in the upper thoracic is 3 cm. and in the lower thoracic or lumbar regions 4 cm. When the needle comes in contact with the nerve the patient will at first experience a sharp pain, referred to the terminal distribution of the nerve, soon allayed by the injection of a few drops of the solution. At each injection 5 to 10 c.c. are used according to whether the injection be made directly into the nerve or about it. In the average case, where fewer laminæ are to be removed, it will be necessary to inject four right and four left spinal nerves.

Doubt may arise in the minds of some as to the possible toxic effects of the drug should the solution penetrate the dural sac. With this in mind, Sawyer in his observations on the cadaver injected a solution of methyl blue with a hypodermic needle directly into the nerve root, but on no occasion was a trace of the strained fluid found either within the dural sac or the cord, and he concluded, therefore, that the possible danger of the fluid reaching the cord directly or indirectly was remote. However, this question of the relative toxicity of paravertebral and subcutaneous injections has occurred to others and has been made the subject of experimental investigation, notably by Murya. Using a novocain solution stained with methylene blue the latter discovered the dye in the urine ten to twenty minutes after subcutaneous and five to ten minutes after paravertebral injections. To safeguard the individual Murya proposes a solution with adrenalin to delay absorption and a 5 per cent. gelatin-saline solution to delay diffusion. Although I have not as yet used this solution, it appeals to me as having merit and well worthy of trial.

As with regional anesthesia elsewhere, owing to anatomical variations and other considerations, the degree of anesthesia may not be complete enough in all cases to conduct the operation

throughout without pain. Under such circumstances supplemental injections of novocain solution may be made, especially in the removal of the spinous processes and laminæ when the needle is introduced directly into the periosteum. Or if need be at this stage for a few moments one may resort to nitrous-oxide anesthesia.

After the spinal canal has been opened subsequent manipulations may require resource to other methods of anesthesia according to the object to be attained. For example, in the removal of tumors attached to the roots or in division of the posterior roots some method must be adopted of controlling or inhibiting pain, and for this purpose I have resorted to the application of stovain on a pledget of cotton. The use of stovain in this way was introduced in my clinic many years ago for an entirely different purpose. Impressed with the fact that manipulation of the posterior roots was an important factor in the production of shock, I searched for a measure of prevention, and, partly from clinical and partly from experimental observations, concluded that the stovain block offered the best protection. A thin pledget of cotton is moistened with a 4 per cent. solution of stovain and brought in contact with cord and roots at the level of operation.

Regional anesthesia is appropriate chiefly for operations in the thoracic region. While a method of paravertebral anesthesia in the cervical region has been elaborated by Braun, the proximity of the phrenic center to the level of injection at least arouses one's apprehension as to the safety of the practice and for this reason I have purposely avoided it. Infiltration anesthesia serves as an excellent substitute for regional anesthesia and I found it perfectly feasible in a patient who, because of pulmonary tuberculosis, seemed an unfit subject for ether nacrosis. Four laminæ were removed and the inspection of the several aspects of the cord was accomplished without discomfort to the patient. Throughout the operation the patient complained of pain only when the posterior roots were disturbed, and had I been familiar at that time with the use of the stovain block every step of the operation could have been made painless.

When called upon to perform a laminectomy in the lumbar region, spinal anesthesia is the method of choice because it is equally, if not more, effective and the technic less complicated. With one insertion of the needle one accomplishes what is difficult by the regional method with eight to ten. The first resection of the posterior roots for spasticity in my clinic was carried out under spinal anesthesia, and because of the necessary manipulation of the roots this form of anesthesia proved particularly appropriate.

In addition to the examples already cited, where I have found it desirable to avoid ether narcosis, there should be included injuries to the cervical cord. The accompanying paralysis of the accessory muscles of respiration predisposes the patient to pulmonary congestion, and use of ether is properly looked upon as injudicious and it is quite feasible to perform an exploratory laminectomy without it.

My purpose in discussing methods of anesthesia other than those usually in vogue has been chiefly to point to ways of reducing such risks as there may be attached to operations upon the spine. By attention to such details the mortality has been so reduced that an exploratory laminectomy *per se* has no more attending dangers than an exploratory laparotomy. All told, there have been but four operative deaths in my clinic following laminectomy, and two of these could not be charged against the operation—one, an acute osteomyelitis of the spine in a profoundly septic patient; the other, a grave injury to the cervical cord. Of the two remaining deaths both followed resection of the posterior roots, one in a defective child of five, the other in an adult.

There are important matters of technic other than the solution of the anesthetic to which I briefly allude in closing: an ample exposure implying the removal in the first instance of an adequate number of laminæ; *x*-ray identification of at least one lamina before the operation, so that the opening corresponds precisely to the location of the lesion; coffer-damming with cotton the spaces on either side of the dural flaps to prevent drops of blood

gaining access to the dural sac, a potential factor in the formation of postoperative adhesions; the gentlest manipulation of the cord or roots and the stovain block as prophylactic against shock; minute closure of the dural incision with fine needles and silk to prevent the escape of cerebrospinal fluid; and careful juxtaposition of each layer muscle, muscle sheath, and intervertebral aponeurosis, together with superficial fascia to ensure maintenance of function and the avoidance of disability after the removal of spines and laminæ. Observing these essential features the performance of a laminectomy may be resorted to with anticipation of the patient's recovery in all but exceptional instances.

A METHOD OF PERMANENT GASTROSTOMY

By FRANCIS T. STEWART, M.D.
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An incision is made from a point just below and to the left of the ensiform cartilage downward parallel to the median line for three or four inches. About two or two and a half inches to the left of this incision a second cut is made, the upper end of which is on a level with the upper end of the first incision, the lower end of which is on the level with the lower end of the first incision. The lower extremities of these incisions are connected by a transverse incision (Fig. 1). The rectangular cutaneous flap thus outlined is dissected free, as far as its base, from the subjacent deep fascia, and the two long margins sutured together with catgut over a catheter (No. 20 French), the eye of which remains uncovered below the lower end of the flap (Fig. 2). The catheter, with its enveloping skin, is drawn to one side, the underlying rectus muscle split longitudinally and a portion of the anterior wall of the stomach drawn from the abdominal cavity. A small transverse opening is made in the exposed gastric wall, the inferior extremity of the catheter pushed into the stomach through the opening and the rim of the lower end of the dermal tube enveloping the catheter sutured with catgut to the edges of the opening in the stomach. The lower half of the dermal tube is buried in the wall of the stomach in the same manner as the catheter is buried in the Witzel operation (Fig. 3). The upper end of the canal thus formed by the inversion of the anterior wall of the stomach is sutured to the abdominal wall and the split rectus muscle approximated with catgut around the

FIG. 1.—Gastrostomy. The cutaneous incision

FIG. 2.—Gastrostomy. Formation of the dermal tube.

FIG. 3.—Gastrostomy. Envelopment of the dermal tube by the anterior gastric wall.

FIG. 4.—Gastrostomy. Cutaneous incision closed.

upper half of the dermal tube. The skin about the raw surface which remains is undermined, and, beginning at the lower left corner of the oblong defect (Fig. 1, *B*), sutured, the sutures being inserted farther apart on the right, *i. e.*, on the line *B C D*, Fig. 1), than on the left (*B A*, Fig. 1), until the lower margin of the external orifice of the dermal tube is reached, when the suture line bifurcates to embrace the new stoma. The scar thus resembles a Y, the long tail of which is slightly convex toward the median line (Fig. 4). The catheter is fastened to the skin with a catgut suture, and should remain in place until the completion of healing, after which it may be withdrawn, to be reinserted only at the time of the feedings.

This method of gastrostomy is designed for those patients, usually suffering from irremovable esophageal carcinoma, who must for the rest of their lives be nourished through an artificial opening in the stomach. The operation is a trifle longer than the Witzel operation, but has all the advantages of providing a canal lined with epithelium, which will not become agglutinated during the intervals between the insertions of the catheter. Further, there is no danger, as in the Witzel operation, of leakage between the outer end of the canal in the stomach and the abdominal wall, and no danger of pushing the catheter between the stomach and the abdominal wall and so into the peritoneal cavity.

A canal lined by mucous membrane can be constructed, as suggested by Depage, Jianu and others, from a flap of the wall of the stomach, and is to be preferred to all other methods of gastrostomy when one desires to build an artificial esophagus, which, later, is to be joined to the external stoma of the canal leading into the stomach, but in the majority of cases of esophageal occlusion the building of a new esophagus is not indicated, and to fashion a mucosa-lined canal from the gastric parietes is more complicated and attended by greater risks of infection than is the operation described above.

In the Ssabanejew-Franck operation, which also provides a lining mucous membrane for the canal opening into the stomach, one must often, in view of the small size of the stomach conse-

quent upon the esophageal obstruction, pull almost the whole stomach from the peritoneal cavity, thus producing serious deformity, before securing the requisite amount of gastric wall to complete the operation. In addition the external orifice of the canal retracts beneath the skin and becomes difficult of access, thus rendering catheterization uncertain and attempts at catheterization dangerous.

We have performed the operation which is the subject of this paper five times. One patient died at the end of ten days from pneumonia. Three lived for periods ranging from three to six months. One lived one year, dying of suppurative cholangitis. This patient had an ulceration of the gullet which was diagnosticated as carcinoma. After several months of esophageal rest, however, the ulcer healed and swallowing became easy. The gastrostomy was therefore no longer kept in use and its lumen gradually contracted, so that at the end of a year only a fine probe could be introduced.

WOUNDS AND THEIR TREATMENT: BASED ON TEN MONTHS' EXPERIENCE AT 16 (PHILADELPHIA, U. S. A.) GENERAL HOSPITAL, B. E. F.

By MAJOR RICHARD H. HARTE, M. O. R. C., U. S. A.
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A WOUND is any breach of surface continuity effected by sudden mechanical force. For convenience wounds are classified as (1) open; (2) subcutaneous; (3) septic; (4) aseptic; (5) contused; (6) lacerated; (7) punctured; (8) gunshot (of different variety); (9) poisoned wounds.

The local phenomena of wounds are pain, hemorrhage, loss of continuity, loss of function, gaping or retraction of the soft parts. These symptoms vary with the size, nature and vascularity of the part affected. Loss of function depends upon the situation, and extent of the lesion. The gaping depends upon tissue elasticity and varies with the part involved. It is often assumed to be due to loss of substances.

RULES FOR THE TREATMENT OF WOUNDS: (1) Arrest hemorrhage; (2) control shock; (3) removal of foreign bodies; (4) asepsis; (5) drainage, approximation of edges and dressing; (6) the establishment of local and general rest.

1. *Hemorrhage.* The arrest of hemorrhage is essential, inasmuch as blood-clots form foci for subsequent infection. Bleeding points are best controlled by means of catgut ligatures; muscular oozing by deeply placed sutures which control larger masses of tissue. Constricting bands such as clothing or dressings must be removed because such constriction results in venous stasis and favors oozing. Persistent oozing is best controlled by (1) elevation of the limb; (2) the application of hot water or

alcohol; (3) exposure to air. Carefully applied bandage pressure may be employed but only if other means have failed, since this procedure is often responsible for discomfort or pain, and if long continued, tissue destruction.

2. *Traumatic Shock.* Traumatic shock is so intimately associated with wounds that more than a passing note should be made. Shock can be described as a depression of the vital functions arising from any injury or profound emotion—characterized by the lowering of the blood-pressure, impaired cardiac and respiratory action, with a decided fall in the body temperature accompanied by profuse sweating. The central venous system is often engorged and the arteries contain less blood than normal. Its physiology, however, has never satisfactorily been explained. Shock is associated with severe traumatisms, hemorrhages, acute toxemias and is aggravated by pain, cold and exhaustion. The treatment should be as prompt as possible. (1) The patient should be placed in a horizontal position, with the head lowered, except when contra-indicated by wounds. (2) Restore body temperature by artificial heat, remove all damp and wet clothing and place the patient between warm blankets. (3) Absolute rest, pain to be controlled by injections of morphin and atropin. Strychnin, adrenalin and camphorated oil have their advocates and do good. (4) Warm intestinal irrigation with normal salt solution to which is added bicarbonate of soda to assist in controlling the acidosis which is susually present. Nausea is frequent, consequently drugs given by the stomach are not absorbed. If hemorrhage has occurred, intravenous injections of isotonic solutions (Locke's fluid), to which may be added 30 minims of 1 to 1000 solution of adrenalin, are indicated. The fluid should enter the vein slowly and be of a temperature of 105° F. Blood transfusions do little good except in profuse hemorrhage. Operation are, as a rule, contra-indicated until reaction has been established. Chloroform is regarded as a particularly dangerous anesthetic in this condition.

3. *Foreign Bodies.* All visible foreign bodies, such as clothing, dirt, bullets, stones or shell fragments, should be removed.

When feasible radiographic examinations should be made to determine the presence and location of foreign bodies, which might otherwise be overlooked. This statement applies especially in case of gunshot wounds.

4. *Asepsis.* The entire process of healing depends on the thoroughness with which the wound is cleansed. The surrounding skin area, if hairy, should be shaved. If the scalp is involved hardly too much hair can be removed, first with scissors, afterward with a sharp razor, soap and water being liberally used. If the wound is lacerated and contused, all tissue regarded as beyond repair must be removed. The skin should be well scrubbed, using a brush, soap and water, the wound itself being protected by means of sterile gauze, following which the skin is painted with tincture of iodin or picric acid solution. Care must be exercised as the excessive use of iodin on a moist and irritated skin may cause blistering. The cleansing of the wound proper is best accomplished by douching or swabbing with an antiseptic solution expressed at a slight elevation, from a swab or syringe. Clots are thus floated off or may be brushed aside. If, as is often the case in crushed wounds, dirt has been forced into the tissues, the use of a clear oil, followed by the application of soap and water, will facilitate its removal. Aseptic wounds should not be irrigated with strong antiseptic solutions, as these tend to cause tissue necrosis. If bone is involved, a curette may be employed to remove imbedded, foreign material. The most reliable antiseptic for badly infected wounds is pure tincture of iodine or pure carbolic acid. Such applications are, however, only justifiable in care of small wounds, and if phenol is employed, its caustic effects must be promptly neutralized by alcohol.

5. *Drainage.* Superficial wounds as a rule require no special drainage provided that they are not too tightly closed. The small quantity of serum which thus escapes is readily absorbed by the dressings. Large and deep wounds require free drainage for at least twenty-four hours. Rubber tubing, horsehair, silk gauze or a small cigarette roll of rubber tissue or gauze may be employed and an aseptic dressing applied. Some prefer to use a dusting

powder such as iodoform, salicylic acid or boric acid or iodid of bismuth. Dusting powders are, however, unnecessary for clean, dry aseptic wounds. In doubtful cases I have felt that iodoform, although objectionable to some on account of its odor, does good. As soon as dressings become soaked with wound fluid they must be changed. A clean incised wound requires careful and accurate approximation of its edges. If the wound is deep, buried stitches of catgut may be employed to prevent dead spaces. Provision for drainage must be made before the wound is dressed with gauze and bandaged. Loose easy approximation is especially desirable in wounds of the face. In other regions wounds may be left open because of the damage to the blood supply.

6. *Rest.* Physiological rest is most important not only for the patient's comfort but also in order to promote healing. If the effects of a wound are severe, especially if symptoms are constitutional (fever, etc.), as well as local, the patient must be confined to bed and appropriate sedatives or hypnotics administered. Local rest is secured by means of properly padded splints carefully applied. The intelligent application of the bandage supports the circulation, controls muscular spasm, and adds greatly to the patient's comfort. The constitutional treatment of infected wounds consists in attention to the bowels and bladder, the administration of nourishing food and the securing of adequate rest and sleep.

Contused and Lacerated Wounds. Contused and lacerated wounds result from a blow or a squeeze which crushes, splits or ruptures the skin. This usually occurs when force is applied directly over a bone. Many scalp wounds are of this character. A "brush burn" is a wound of this type, due to friction. All hopelessly damaged tissue should be removed, but doubtful tissue should be allowed to remain. If, as is usually the case, the wound is infected, antitetanic serum is indicated. Cold applications are undesirable because they tend to diminish the rate of local blood flow and thus reduce the vitality of the part. Heat which has the contrary effect is most desirable. It is advisable to dress from the start with some antiseptic solution. If sloughing begins it is

important to cleanse the wound quickly. Nothing accomplishes this more promptly and with greater comfort to the patient than a well made flaxseed poultice, the efficiency of which has been lost sight of by the profession. Large, wet, hot saline compresses may, however, be employed.

Punctured Wounds. Punctured wounds made by pointed objects, such as nails, bayonets, knives, etc., are usually small in comparison to their depth. Much septic material may be forced into the wound with but little opportunity for its escape. Owing to the elastic contraction of the skin, blood and wound fluid tend to be retained and the deposit of pyogenic or tetanic organisms with their development is thus favored. All punctured wounds should be considered infected. Hence thorough disinfection of the skin, incision or excision of the soft parts, douching of the wound with antiseptics, and the establishment of drainage, are indicated. Often it may be advisable to wipe the infected tract with pure carbolic acid or tincture of iodin, an antiseptic dressing being thereafter applied. If infection has actually begun the part must be freely incised and every attempt made to control the acute inflammatory action which has started.

Gunshot Wounds. Gunshot wounds are of the contused, lacerated variety and may be produced by any material projected by explosive action. They may be caused by bullets, bomb or shell fragments, pieces of rock or gravel or other material forced through the skin. The wound of entrance is not an index of the destructive effect within, and owing to cutaneous elasticity, the wound of exit is often larger than that of entrance. The most destructive effects occur as a result of the ragged fragments of bombs and high explosive shells. These fragments which may be of any conceivable size and shape, are especially injurious to bloodvessels and nerves when they are thin and scale-like with sharp edges. High velocity bullets not infrequently produce small, clean, relatively aseptic wounds which heal promptly, causing little or no disability. A similar missile striking a bone may, however, cause a comminuted fracture with the most extensive damage to the soft parts. This damage of the soft tissues is

often the result of violent dislocation of the bony fragments. For example in chest wounds the most serious damage is often caused in the lung, not by the bullet itself but by the fragments of splintered rib which cause extensive laceration. The destruction of the soft parts which results from shell fragments is at times terrific, and may involve the almost entire loss of the buttocks, an arm, the scapula or a large portion of the chest wall, thus exposing the thoracic or abdominal viscera. Strange as it may seem, some of these cases, gathered from the field, live to reach the C. C. S. (the equivalent of the evacuation hospital, U. S. Army) for treatment. The frequently multiple character of these wounds is a most important factor in their treatment, inasmuch as the patient may have wounds of the leg, arm and thigh, together with a dozen or more small shell fragments lodged in the back. If carried out by a single surgeon, the process of cleansing and dressing is a slow procedure. Hence in order to expedite the dressing and to reduce the amount of anesthesia and the danger of shock, several assistants should simultaneously work on the different parts involved. Hemorrhage in gunshot wounds may at times be profuse and is often concealed; causing a false aneurysm or a large hematoma. Such cases require free incision, evacuation of blood clots and ligature of the bleeding vessels. Secondary hemorrhage not infrequently results from dislodgment of a clot from ulceration of a wounded vessel.

Gas Gangrene. One of the most serious and dangerous complications of gunshot wounds especially of the bomb and shell variety, is gas gangrene, produced by the introduction of clothing or dirt into the wound which conveys some gas forming bacteria, usually the bacillus aërogene capsulatus or some other anaërobic organism into the injured muscle fibers. This infection is much more frequent in trench fighting than in the open or at sea. The rapid spread of the infection is due to the peculiar characteristics of the muscular structure, the sheaths of the muscles being so easily detached as to form potential spaces into which toxic material can readily pass causing necrosis of the fibers. This serves to explain why such rapid and destructive changes take

place, particularly so if the vitality of the part is affected by the destruction of a large and important artery. The destructive effect often seems to be confined only to the injured muscle and shows little or no tendency to invade uninjured muscles except if the blood supply is cut off. The anaërobic infection is often aggravated in its effects by the association of other microörganisms of the putrefactive group especially the streptococcus. Some of the abscesses and sudden toxemias found in gas gangrene may be aggravated by an acidosis both local and general. The treatment of gas bacillus infection must be active and vigorous: First, freely enlarge the wound and dissect away all injured and discolored muscles, until nothing remains but healthy tissue of normal color. The dressing should be light and simple, and must not exclude the air; intermittent irrigations following the Carrel method are useful. If the wound follows an amputation, the flaps should be left open and stitched back permitting free access of air and if possible the wound should be exposed to the direct rays of the sun or artificial light in some form. If a destructive agent is sought for, Taylor advises a one-tenth per cent. solution of quinin hydrochloride in normal saline which has proved experimentally much more active against the organism than any other agent. It must be borne in mind that wounds infected with either gas bacillus or the bacillus of malignant edema are prone to secondary hemorrhage, probably due to the necrosis of the vessel walls or to the digestion of the clots or plugs in or about the vessels. It is also thought that some of the hypochlorite solutions predispose to bleeding by early washing away of supporting clots and fibrin.

Tetanus. Another one of the anaërobic infections, tetanus, occurs frequently in the same type of wound as gas gangrene. It would appear from the nature of the infective material that every case of gas gangrene must be filled with the germs of tetanus which fail to develop owing to the prophylactic dose of the antitoxin which every man receives at the field ambulance or dressing station the dose being 500 to 1500 units. It is advisable that severe injuries such as compound fractures receive a second

injection of 1500 units within six days. The early débridement of the wound as now practiced is also a most important prophylactic measure in preventing tetanus and gas gangrene. In our experience over a period of nine months in a Base Hospital where 17,000 cases were received, not a single case of tetanus developed.

Poisoned Wounds. Poisoned wounds are those in which some chemical or toxic bacterial substance is introduced; many of these wounds are of the "mixed infection" variety resulting from tooth injuries either animal or human or from the bites of insects or from such a toxic infection as anthrax. They require prompt and vigorous treatment and are often accompanied by profound local and constitutional disturbances, a marked angioleucitis of the limb is often present, with involvement of the glands of the groin and the axilla. Almost always one of the early symptoms is a decided chill followed by fever. The treatment in these cases should be prompt and vigorous. Laying the infected part thoroughly open, with free drainage, often completes disinfection of the part. If disposed to travel up the extremity a circular blister will often assist in limiting the invasion.

Treatment of Wounds in General. The wounded that are received at the field hospital and casualty clearing station (evacuation hospital, U. S. Army) have had some attempt made at sterilization on the field by the use of the first aid packet carried by the men. In large multiple wounds, little can be accomplished by this method. It is only at the casualty clearing station that the first systematic examination and, in some cases, the location of the foreign body by the roentgen-ray becomes possible. The removal of foreign bodies is imperative in most cases, especially of particles of clothing which are one of the richest sources of wound infection. In a large base hospital in every case of gas gangrene which came to autopsy, a small fragment of clothing was found embedded with the foreign body deep in the tissues. If the gravity of the case does not warrant amputation, the edges of the wound are excised and all infected and devitalized tissues removed. The tracts are douched with hypochlorite solution, loosely packed with gauze and Carrel tubes inserted for inter-

mittent irrigation. If the Carrel-Dakin treatment is difficult to introduce or the wounds are too numerous, *e. g.*, as on the back or buttocks, the excised surfaces are freely covered with bismuth iodoform paste and a protective dressing of gauze applied. These cases as a rule do very well but the convalescence is always slow as the wound heals by cicatrization and contracture. If gas infection is suspected, free incision and drainage of the wound is the method pursued, especially if the case is to be evacuated to another hospital.

The operative sterilization, as advocated by Depage and the French school, known as "débridement," means a careful opening of all recesses of the wound and minute search and removal of all foreign bodies and especially fragments of clothing. The greatest care must be exercised in the removal of all devitalized tissues and fragments of bone separated from the periosteum. This dissection must be performed with a sharp instrument and great delicacy be employed in dealing with the tissues. It requires much time and care and on its thoroughness depends the control of the infection. The general adoption of this method is largely responsible for the control and diminution in the number of cases of gas gangrene.

After careful débridement has been accomplished, either of two methods of closure may be adopted: (1) The wound may be treated by primary suture and closure with or without drainage, care being taken to avoid any dead spaces; gauze is applied liberally and the patient kept quiet and not transported for a week. (2) The wound may be treated as an open wound, sutures introduced but not tied, and loosely packed with gauze, followed by a liberal dressing and provision made for mobilizing the limb. On arrival at the base, if the patient's general condition permits he is taken at once to the operating room. The dressings are removed with strict aseptic precautions, the packing removed and the previously applied sutures adjusted with accurate approximation of the wound, care being exercised to avoid dead spaces.

The French had pursued this method of treatment with most

gratifying results, closing permanently 80 per cent. of the cases, many of these wounds being compound fractures of the long bones, thus reducing the time of convalescence and the avoidance of troublesome scars resulting from the slow granulating process.

All cases evacuated from the C. C. S. should be plainly indicated by marking on the envelop the type of wound, whether primary or for secondary closure.

The ideal wound is the clean, dry incised one with accurate skin approximation, which heals and leaves a clean, linear scar which assumes in a short time the characteristics of the surrounding tissue and is not influenced later by climatic conditions, and is in marked contrast to the wound which closes by contraction and cicatrization. In the latter variety, when healed, the wound surface is often of considerable extent, ill-nourished, the surface blue, cold and liable to break down, forming into small ulcerated patches on its surface and particularly so in cold weather. Such surfaces bear pressure poorly, which is one of the difficulties often seen in old amputations. The ideal dressing for the clean, incised wound is the ordinary aseptic gauze which has been thoroughly sterilized by heat. It is non-irritating and protects the injured part perfectly. When the wound is large and approximation is impossible, either due to infection or loss of substances, or when superficial sloughing may take place, some wet antiseptic dressing may be desired either in the form of an aqueous or oily solution associated with as thorough and perfect drainage as possible.

The work of Carrel on healing or disinfection with Dakin's solution deserves special attention; and when conditions are favorable, most satisfactory results can be obtained, in which large wounds can be cleansed in from ten to thirty days and then permit of secondary closure. With proper surroundings this method is ideal but difficulties arise in the transportation of patients in ambulance trains and also in wards of temporary hospitals in cold weather, where the solutions freeze and the parts exposed are cold and wet. To obtain perfect results from its use, the surgeon must be thoroughly conversant with all the technic

and the solutions must be kept up to standard and contain their full amount of chlorine. The necessary drainage is obtained not from the tubes in the wound but from the continued overflowing presence of the solution which keeps the wound free from secretion and its puddling process in time rendering the wound sterile. In intelligent hands ideal results may be procured, but under certain unfavorable conditions its proper application may be impossible.

Eusol. Eusol is a most efficient antiseptic solution, closely allied to Dakin's fluid and employed in the same way. It is easily prepared and keeps well in ordinary bottles. This chlorine preparation, unlike Dakin's fluid, is stable and therefore is available in situations where there is no chemist at hand to furnish the freshly made solution.

Dichloramine-T. Dakin simplified the technic of wound treatment by advocating the employment of an oily solution of dichloramine-T in eucalyptus and paraffin oil. Here the destructive agent is dichloramine-T, which in contact with the tissues gives off chlorine and should in a short time result in the destruction of all septic material. It is claimed by its advocates that it hastens the removal of sloughs, stimulates granulations, reduces pus formation, quickly renders a wound sterile and favors the way for early secondary closure. It has also been shown that much less gauze is used in dressings, which are more easily and painlessly removed from the granulating surfaces. For compound fractures and deep suppurating tracts it appears to be less reliable and slower in its action than the Carrel-Dakin method of frequent douching through tubes. Dichloramine-T solution costs about $5.65 per liter and contains 5 per cent. dichloramine in equal parts eucalyptol and paraffin oils. On account of the increasing rarity of eucalyptol, a new solvent "Chlorcosane" is now also supplied. The antiseptic is usually sprayed over the surface through an atomizer or brought in contact with the wound by saturating gauze which is laid over the granulating surface. It is found that for wound treatment the atomizer is preferable to any other method as the stream of air from the

atomizer forces open the wound cracks and crevices, which would otherwise by any other method escape detection. It also makes it unnecessary to touch the wound with the hands or instruments. If a greater amount of solution is desired on the wound, it can be accomplished by the saturated gauze method. For superficial wounds and granulating surfaces it should be a quick, reliable method of early sterilization, rendering the surface suitable for skin grafting by some of the various methods.

Bipp. An antiseptic paste called "Bipp," from the initials of its components, was introduced by Professor Morrison. It is a mixture of bismuth two parts, iodoform one part and paraffin sufficient to make a paste. Its active principle undoubtedly is the iodoform which it contains. It has met with great favor by many of the surgeons at the C. C. S. and is applied to fresh wounds and missile tracts preparatory to placing over the wound the final dressing of gauze. Like every useful remedy it must be employed intelligently and only a very thin coat should be distributed over the surface of the wound; in long missile tracks the surfaces can be reached only by the introduction of a suitable piece of gauze in the form of a tent in which the paste has been thoroughly incorporated. By drawing this through the wound backward and forward, a certain amount can be evenly distributed over its surface, thus avoiding any danger of blocking up the track. The manner in which it is frequently and disadvantageously employed is to fill the wound or track with the substance, literally blocking it up. It thus acts as a foreign body (as may be seen in any skiagraph), which has to be removed on the patient's arrival at the base. Its indiscriminate use has led to many cases of iodoform and bismuth poisoning with symptoms which were often attributed to infection.

Flavine (pro and acri). Flavine has been employed and has found favor with some, but after it has been in contact with the granulation for about a week it appears to lose its efficiency. The granulations are inhibited by it, and cease to develop, until it is replaced by Dakin's solution or other method of treatment which restores their activity.

Hydrogen Peroxide. Hydrogen peroxide is a valuable detergent for the cleansing of purulent and sloughing wounds, suppurating tracts and sinuses but should never be used on sterile wounds. It should never be injected in a cavity that has not a free outlet as the sudden ebullition of gas may be sufficient to tear out the retaining stitches or spread infection into normal tissue. Hydrogen peroxide is not destructive to tetanus bacilli and in fact tetanus bacillus can be cultivated in a strong solution of it. It is perferable to have the peroxide injected from a glass syringe and permitted to remain in contact with the wound for a short time. After the effervescent action has subsided, the débris should be removed with warm saline solution preparatory to the final dressing. It is a valuable adjuvant in the separation of gauze packs which have been placed in wounds or tracts either for drainage or for the control of hemorrhage. The fluid should be injected from the nozzle of a syringe deep into the gauze folds and permitted to remain there for a short time until the gauze is thoroughly impregnated, thereby separating the entangled tissue from the mesh of the gauze. The offending packs can then be easily removed by gentle torsion until complete separation is accomplished. By this means much pain and distress are avoided and the necessity of an anesthetic obviated.

Secondary Suture. Here at this point the question of secondary closure of wounds should be considered. The best method of wound sterilization, whatever it may be, is the one that destroys all bacteria and permits the freshening of the edges and closing after the manner of a recent wound. The proper time for closure can be determined by smear examination or culture. As soon as the wound is under treatment, a daily record and chart should be prepared and the changes noted in the number of bacteria in each field. The material selected for examination should be taken from the least desirable portion of the wound usually in the less superficial excretions. The deeper granulations should be examined by removing a portion with a wire loop. When the number of microbes has diminished progressively and remained at zero, or less than one organism for five fields, for two or three days, a

degree of asepsis has been reached which will admit the suturing of the wound with reasonable safety.

The time required for the sterilization of an ordinary infected wound of the soft parts may vary from eight to twenty days, depending largely on the virulence of the infection. In compound fractures with great involvement of bone the sterilizing process will naturally be much delayed or in some cases impossible. The advantages of secondary wound closure are the saving in labor and time of treatment, the diminished risks from infection, the production of a linear scar free from cicatricial tissue and one that is not subject later to climatic changes. The advantages are so markedly superior to the old method of treatment that every effort should be made to prepare the wound as early as possible for secondary closure. The after-treatment is that of an ordinary incised wound.

All secondarily closed wounds bear transportation badly and if possible enforced rest should be demanded. If this is impossible, the part should be carefully splinted to insure the best local rest possible in transit.

It should never be lost sight of that a granulating wound is really a healing ulcer which closes by cicatrization and contracture. It is a much slower process than the healing of an incised wound by first intention. As granulations develop to a higher level on the surface, the area of fibrous tissue becomes broader at the base and the margins, and this young fibrous tissue contracts. This contraction draws the edges of the wound together and thus reduces the surface which must be covered by epithelium. This is proliferated only from the epithelial margin and consists of a bluish opalescent film extending over the granulations. In treating a wound the object is to dress it so that this new epithelial growth will be encouraged and that the dressing shall not destroy or injure it on removal. To encourage rapid healing, the granulations must be dressed with some bland or at times stimulating ointment, *e. g.*, scarlet red (8 per cent.) for twenty-four hours. It has long been noted by careful observers that the granulations become tolerant of any special dressing if persisted in for a week

or more, so that the reparative process is greatly retarded. On changing to some other dressing, new life is infused into the granulations which previously had become pale, flabby, almost watery in appearance, or at times very dark and congested and ready to form superficial sloughs over the surface. This is due to an impaired blood supply which has been caused by the formation of a stagnant bank of lymph in the next vascular area.

The prevailing dressing for these granulating wounds (ulcers) is the ordinary aseptic gauze. Although ideally suitable for closed incised wounds with accurately approximated margins, it is a most unsuitable dressing when placed on a granulating surface, as the granulations in their growth soon become entangled in the meshes of the gauze and on removal all the reparative processes of the previous twenty-four hours are destroyed by the tearing away of the delicate epithelial proliferation from the margin of the surface.

To obviate this, these ulcerative surfaces can be dressed in a great variety of ways. It must be accepted that these healing ulcers are all mildly infected as noticed by the character of the discharge which varies according to the virulence of the infection. There is almost no end of material that may be employed to advantage in wound dressing, such as neutral and stimulating aqueous solutions, various forms of ointments, simple protection such as rubber tissue applied under the gauze to prevent sticking, exposure to violet rays of electric light, simple air or to direct sunlight. All of these methods have their advocates and under favorable conditions desirable results are obtained.

To hasten the repair and close a granulation on an ulcerated surface with a satisfactory continuous covering, certain methods should be employed which will hasten the reparative process: (1) The skin surface in the wound area should be thoroughly cleansed and kept in a perfectly active and healthy condition by thorough daily cleansing with soap and water and alcohol. (2) If the surface of the wound is covered with sloughs and débris, their separation can be hastened by a wet saline solution on a properly made and applied flaxseed poultice changed night and

morning if necessary. There are certain wounds on the face and the extremities which are distinctly indolent and fail to respond to any treatment, particularly if the wound has a hard indurated base and is poorly nourished. Nothing will change its character if on the extremities like a moist, liberal saline dressing over which is applied an Esmarch or Martin rubber bandage sufficiently tight to cause a fair degree of pressure. What is preferable if the surgeon's prejudice will permit him to use it, is a carefully made flaxseed poultice. It should be thoroughly boiled and to it added sufficient salt to make it slightly saline. The surface should be covered with several layers of gauze to prevent the escape of the flaxseed. This is laid over the part as warm as possible and retained by the above mentioned bandage. The dressing will retain its moisture twenty-four hours and its temperature can easily be maintained from 105° to 110° by the use of a hot-water bag. The immediate improvement that will take place in a wound thus treated is most noticeable.

In burns, particularly of the face, a poultice can be laid over the surface which assists measurably in cleansing it of sloughs and scabs preparatory to some later form of treatment. It retains its moisture, being slightly saline and is most agreeable to the patient.

After the separation of sloughs, the edges of the wound should be supported and approximated as much as possible by carefully applied strips of adhesive plaster with a long firm attachment on either side which assist greatly the contracting process. In applying the plaster it should never encircle the limb. On the finger it is preferably applied in a spiral manner which assures no interruption of the circulation. If the wound is a stump involved following amputation of the fingers, two crossed strips are advisable supported by a circular strip to insure support. The strips should be removed each day, alternaing the position of the strips at every dressing. When the strips have been applied the remaining surface should preferably be covered with some suitable ointment (*i. e.*, zinc, resin, boric or scarlet red), which insures protection to the granulations and encourages healing.

Whatever ointment is selected, it should be spread thickly on the smooth side of the lint and only of sufficient area to cover the granulating surface and not smeared over the entire wound area. To insure the escape of wound secretion, several slits should be made in the lint after being spread with the ointment. It is covered with cotton or some absorbent and retained by a suitably applied bandage. At times the granulations may be exuberant and extend above the skin surface, in which case the application of nitrate of silver is advisable, cutting down the "proud flesh," as it is often termed. If the granulations are pale and edematous, glycerin, when procurable, by its hygroscopic properties makes a satisfactory temporary dressing. A ten grain to the ounce solution of copper painted over the surface has a mildly stimulating effect. When too much stimulated, the granulations are liable to bleed freely and sloughing of the surface and of the newly laid down material results. In large open surfaces the healing processes can be hastened greatly by skin grafting in some of its various forms.

There are many methods of wound treatment and unfortunately no panacea presents itself which will meet all conditions. As wounds differ in character at different periods of their treatment, so that that which is applicable at one stage, will be unsuitable at another. The best results can only be obtained by the surgeon who possesses experience and exercises his judgment in dealing with the problems by which he is constantly confronted.

RECEIVING AND OPERATING PAVILIONS FOR A MODERN BASE HOSPITAL[1]

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It is the purpose of this communication to describe the adaptation of standard barrack buildings to the uses of receiving, bathing, operating and *x*-ray pavilions in a base hospital. The buildings described form part of Base Hospital 34, American Expeditionary Forces, which is situated in the outskirts of a large city, at a considerable distance from the front.

It is believed that the use of barrack buildings for these purposes has distinct advantages even when buildings of permanent construction are available. In the case of Base Hospital 34 there is a large, new, modern building of stone and reinforced concrete, which accommodates in itself 1100 beds. It would have been quite possible to have utilized rooms in this building for receiving bathing, operating and *x*-ray departments; but I believe that no building originally constructed for other than hospital purposes will lend itself so admirably as do these barrack buildings to the purposes indicated, since only the four outer walls limit the arrangement of the interior.

The barrack buildings employed at Base Hospital 34 are of what is known as the Fender type, from the name of the manufacturer. The "life" of these buildings is said to be from three to seven years, without noteworthy repairs. They are composed of uniform wooden panels, each 2 meters in width and $2\frac{1}{2}$ meters high, made of two thicknesses of wood, with an intervening air space of 7.5 cm. Each panel, technically speaking, includes the opposite sides of the oblong rectangular building, with the corresponding sections of roof and floor. The roof also is of two layers of wood, separated by an air space, and is covered

[1] Recommended for publication by the Chief Surgeon, American Expeditionary Forces.

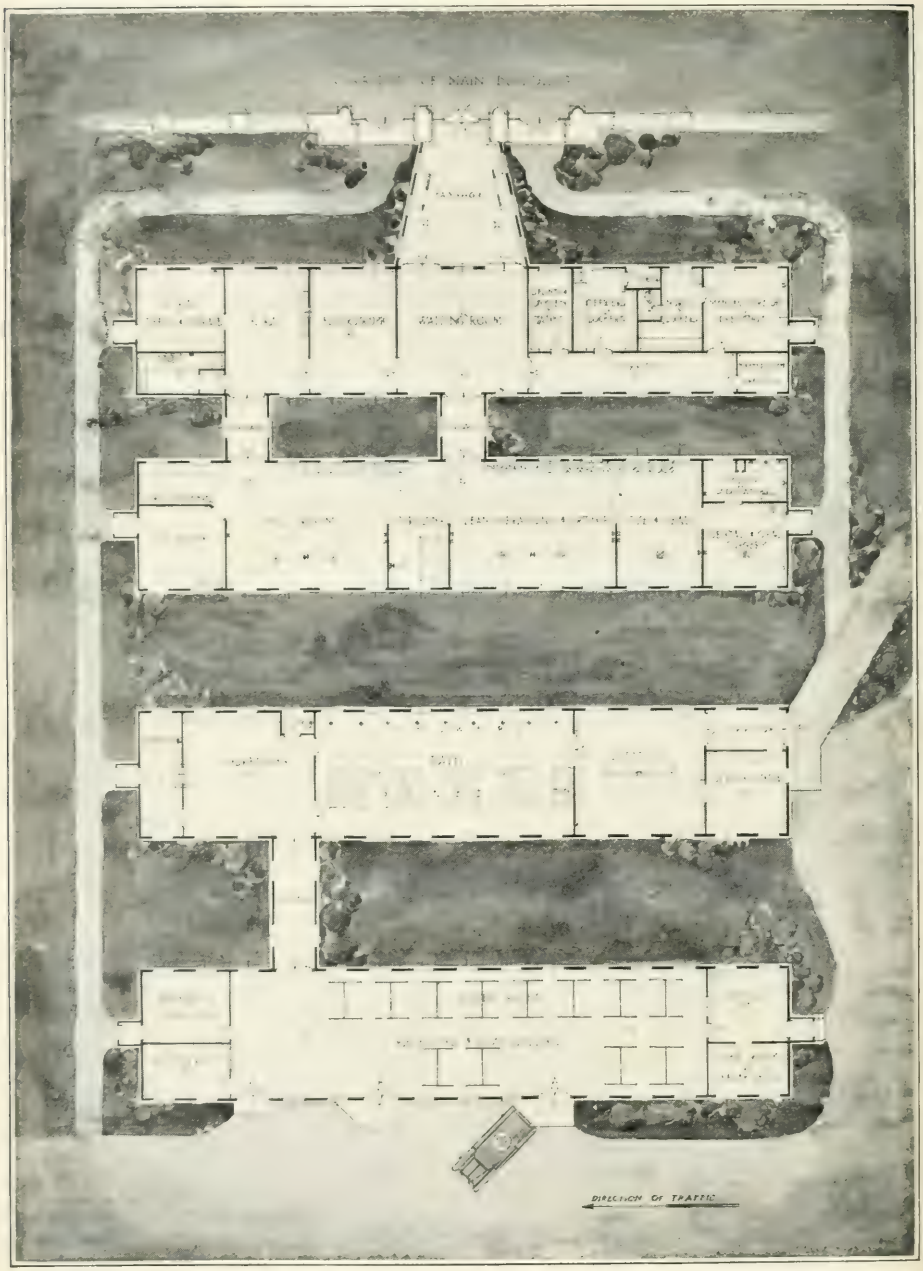
on the outside with tarred paper. It rises to a peak four meters high and is ventilated about half-way up the slant.

The buildings may be made of any desired length, but are all of uniform width of 6 meters. Those in use for various purposes at Base Hospital 34 vary from one which is only 6 panels long (baths for enlisted personnel) up to a number which are 23 panels in length (about 150 feet). These latter serve as wards, with accommodations each for 50 beds.

The rapidity of construction is remarkable. The panels fit together with surprising accuracy, and are fastened by bolts. The enlisted men of the Medical Department, attached to our hospital, learned the mechanism from the French within a very short time, and succeeded in erecting several 15 panel barracks in an average time of one and a half to two days each. This, however, does not include the time necessary to prepare piers for the floors, which may demand two or three days' preliminary work. The piers are made just high enough to bring the buildings level, and their use thus does away with the necessity of grading the ground. If cement floors are employed grading is necessary, and there is also the delay required for the cement to set. But if all the materials are at hand, it should not require more than two weeks to construct one of these pavilions.

The four barrack buildings about to be described are placed in a large level courtyard formed by the three wings of the central building of Base Hospital 34. They are of uniform dimensions, 6 x 30 meters. The building nearest the entrance road is the receiving ward; adjoining this, and connected with it by a covered passage, is the bathing pavilion. Parallel with these, but 6 meters distant, is the operating pavilion, while close to this (3 meters distant) is placed the pavilion devoted to *x*-ray laboratories and to dressing rooms for surgeons and for nurses, and a room for the manufacture of surgical dressings. The relations of these buildings are shown in the accompanying plot plan.

The floor of the receiving pavilion is of wood; that of the other three buildings of cement, which is relatively abundant in France, and which certainly makes much more suitable flooring for bathing and operating rooms than does wood. All four buildings are heated by a central hot-water heating system.



Court Buildings, Base Hospital 34, U. S. A., American Expeditionary Forces.
Scale, 1 centimeter = 1 meter.

As designed by the manufacturers, each alternate panel contains a large window, the intervening panels having small windows placed 2.75 meters from the floor. But as the panels are interchangeable, it was possible in constructing the operating pavilion to place all the large windows on the same side, while beneath the small high windows, thus coming to occupy the opposite side of the building, all plumbing fixtures were conveniently located. A similar arrangement in the bathing pavilion afforded accommodations along the rear wall for a row of shower baths. The floors of the bathing and operating pavilions are constructed with a broad shallow gutter along one side, thus facilitating cleaning and drainage. Owing to the solidity of the floors it was possible to construct all partitions of tile and plaster. The interior of the buildings is painted, that of the operating pavilion being tinted a very pale green. This, with four skylights, gives ample daylight. Artificial light is electric; and gas has been introduced for emergency use.

Admission of Patients. The incoming ambulances drive up from the east side, and back against the obliquely placed platforms to discharge their loads. By being placed thus obliquely in the road, a clear passage-way is left for other traffic beyond the ambulance; and the ambulances are enabled to continue on their journey westward, after discharge, without the additional backing maneuvers which would be required if the ambulance bodies were stationed at right angles with the road when discharging.

The patients on litters are carried, and ambulatory patients walk, directly into the receiving ward, through doors A and B, where the litters are placed on racks. The litter bearers at once rejoin their ambulances, passing out by door C, and carrying with them fresh litters. Attached to the receiving ward is the office of the officer of the day, as well as his bedroom; at the other end of the ward is a scullery, from which hot coffee may be served, and a minor operating room, in which patients may be catheterized, their dressings temporarily rearranged, and intravenous saline infusions administered. The following regulations are in force:

"A waterproof tag will be attached to the wrist or neck of every patient as soon as he enters the receiving ward. On this tag will be noted the patient's name, the tentative diagnosis, and the ward to which he is assigned. After these data have been thus attached to the patient, the diagnosis tags which accompany him from his last station will be removed and from them will be made the necessary records (Forms 52, 55a and 71 MMD).

"After such emergency treatment as required (Scullery and Minor Operating Room), the patient will be removed to the bathing pavilion by attendants coming thence.

"In the undressing room he will be completely unclothed; only such surgical dressings as are indispensable and the patient's waterproof tag will be retained. His soiled clothes will be listed in duplicate (Form 75, MMD), will be tied loosely in a bundle, the bundle will be tagged (Form 76, MMD), and it will be passed through the window into the disinfecting room. After disinfection they will be turned over to the non-commissioned officer in charge of the storeroom for patient's effects.

"The naked patient will be carried by attendants from the undressing room into the bath room. Patients who can walk may take shower baths. Other patients will be placed on the washing slabs, where they will be thoroughly cleansed with soap and hot water. The hair of the head of all patients, and that of their bodies when necessary, will be closely cropped or shaved. After being dried helpless patients will be carried into the dressing room by clean attendants from that room. The bath attendants will carry patients neither into nor out of the bath room.

"In the dressing room the patients will be given hospital bedclothing, and will be carried to the proper ward by ward attendants. On leaving the dressing room the non-commissioned officer from the receiving ward will see that Form 55a (the "Clinical Brief" of the history) is attached to the proper patient, using the waterproof tag for identification."

The clothing of incoming patients is disinfected in a steam sterilizer, adjacent to the undressing room in the bathing pavilion. The washing of the patients is much facilitated by the use of slabs instead of bathtubs, though one tub is provided. These

slabs are of slate, draining to a deep gutter on all sides, and the gutter draining at the foot of the table, the frame of which is constructed of iron piping. It is only when they are placed on the washing slabs that the patients are first moved from the litters on which they have been transported. The soiled litters are cleaned, and are carried back into the receiving ward when the attendants in the undressing room make one of their trips into that ward for other patients.

The Operating and X-ray Pavilions. These are only 3 meters apart, and being joined by two wide passages form almost one continuous building. They are approached through a wide covered passage-way leading from a recovery room in the center of the main building. Opening out of this recovery room are two surgical wards, with accommodations for 75 beds; while a barrack ward, of 50 beds capacity, is accessible only 3 meters distant on the other side of the main building. Thus there are available, on the ground level, 125 beds for patients recently subjected to operation, where they may be kept until it is safe for them to be removed to more distant wards.

In the *x*-ray department are fluoroscopic and radiographic rooms, an office, and the darkroom. These rooms connect by a short wide passage with the operating rooms.

The other end of this *x*-ray pavilion is devoted to dressing rooms for surgeons and nurses, and a room for the preparation of dressings for sterilization. As the dressings come to us already made, through the intermediary of the Red Cross, it is necessary for our nurses only to sort the ready-made dressings into packages suitable for sterilization. Until they are needed for sterilization the dressings are stored in a closet next the nurses' work room. There is also a large closet for storage of blankets, splints, oxygen tanks, plaster of Paris, etc.

There are several well-lighted rooms available for purposes of anesthetizing patients; this may be done in the wide passage-way leading from the recovery room to the waiting room, in the waiting room itself (when not otherwise occupied), in the corridor to the east of the waiting room, or in one of the operating alcoves not in actual use.

In the operating pavilion proper there are accommodations for seven simultaneous operations — a limit which is not likely to be often exceeded. Specifically there are accommodations for oral surgery, including dental operations, with a well appointed dental laboratory for manufacture of prostheses immediately adjacent; an alcove for head surgery in general, including also the eye, ear, nose, and throat; an alcove to accommodate two tables for orthopedic and other aseptic operations; another accommodating two tables for septic cases; and a room for genito-urinary surgery. The steam sterilizing apparatus is placed near the center of the pavilion, and ample accommodations are provided for storing sterile dressings near at hand.

In planning this operating pavilion it was determined to attempt a happy medium between the grand saloon type of operating room, where there are no partitions whatever, and the type where each operating table has its special room. The latter plan lacks economy in administration, many more attendants are required, and time and labor are lost by walking around so many corners instead of going directly to the place desired. The former plan, where numerous operators work simultaneously in the same large room, does not always tend to quiet and discipline, and injurious draughts may arise. By employing partitions 3 meters long (which reach half across a barrack building of this type), it was possible to form alcoves of sufficient depth to afford relative isolation for the operating teams; and by arranging that the two alcoves in most constant use should each be of sufficient size to accommodate two tables when necessary, it became possible to reduce to the minimum the number of attendants required, as one sterile-handed nurse may easily conduct a suture table for two simultaneous operations.

My thanks are due to many members of our professional staff for suggestions of value in connection with the construction of these buildings, and especially to the Chief Engineer Officer, Major Fowler, for procuring material and giving us opportunity to use it as we deemed best. I have also to express indebtedness to Corporal Hoke and Private Stern for their architectural knowledge and for drawing numerous plans.

REPORT OF THE COMMITTEE ON FRACTURES

REPORT OF 1916

COMMITTEE

Dr. John B. Walker
Dr. Thomas W. Huntington
Dr. Edward Martin
Dr. Astley P. C. Ashhurst
Dr. W. L. Estes
Chairman

Synopsis. Form of record and schedule adopted by railroad companies and societies.

According to the program and the directions contained in the Resolution adopted by the Association at its last annual meeting, the Committee on Fractures has this year only made preparation for its final report.

As the Association recommended, the form of record and schedule of fractures adopted by the Association last year were presented to and adopted by the Surgical Section of the American Medical Association, were sent to all the principal railroads and industrial establishments of the East and Middle West, and the standard form of record was adopted by most of them. It was also formally adopted by the New York and New England Association of Railway Surgeons, by the National Conference on First Aid, by the Pennsylvania Railroad Surgical Association, by the Medical Society of the State of Pennsylvania, by the Medical Department of the United States Army, and by the United States Public Health Department.

Besides these organizations, a number of industrial corporations and hospitals have taken the blanks as their models and have furnished their institutions with similar blanks.

The Committee has sent out to date 7500 of these blank reports.

The general adoption of these forms is encouraging, but it will do little good unless the records are faithfully kept, and unless

these records, when properly completed after the patients have returned to work, are sent to the committee for analysis and included in its final report to this Association.

The Committee begs, therefore, every Fellow of this Association to use his influence and efforts constantly to see that these reports be kept faithfully and fully, and to have copies sent to the Committee when the records are completed.

The Committee will endeavor from this time on to collect and collate these reports, and hopes next year to be able to make its final report.

REPORT OF 1917

COMMITTEE

Dr. John B. Walker — Dr. Edward Martin
Dr. Thomas W. Huntington — Dr. Astley P. C. Ashhurst
Dr. W. L. Estes
Chairman

Though the Committee sent out 6850 copies of the official blank for collecting data, and directly or through the assistance of the associate members throughout the United States and Canada enlisted the promised help of many hospitals and a large number of industrial establishments and railroads, the chairman received only 79 reports from these establishments and railroads.

The Surgeon-Generals of the Army and Public Service Department also adopted the form, and from these services 149 reports were received.

The several members of the committee have collected from their own services and hospital connections something like 350 reports.

Obviously these data are not sufficient upon which to base the conclusive standardization for which the committee is working.

The Workmen's Compensation Board of Pennsylvania has officially adopted the Association's forms of report, and has agreed to give the committee the benefit of its collection.

By persistent effort through another year hospital surgeons and hospital managements may be induced so to record their cases of fractures that your committee may receive sufficient data to make a final report, one of value and importance.

The committee therefore reports progress, and leaves to the Association the determination as to whether or not the committee shall be continued.

The committee wishes gratefully to acknowledge and to express its thanks to the Surgeon-Generals of the Army and Public Service Department for their help. Also, the committee wishes to mention and to extend thanks for special assistance given by our Associate Members, Drs. Thompson, of Galveston, and Jonas, of Omaha, in collecting and sending in the only reports received from railroads.

REPORT OF 1918

COMMITTEE

Dr. John B. Walker
Dr. Thomas W. Huntington
Dr. Edward Martin
Dr. Astley P. C. Ashhurst
Dr. W. L. Estes
Chairman

It will be recalled that in its preliminary report in 1915 it was stated by the committee that it had set itself the task of trying to determine three points in regard to fractures of the long bones, namely:

1. To find out the average present-day result in both simple and compound fractures, as regards anatomical and functional results, in the several age groups and the average time of disability. This latter period is determined to mean the average time the patient lost from work or from his ordinary duties.

2. The comparative value of (*a*) the conservative or closed methods, and (*b*) the operative or open methods.

3. The comparative value of immediate or delayed treatment in each group of cases.

To carry out this plan it was necessary to obtain and to analyze a large number of well-kept and fully registered fracture records.

The committee based its preliminary report on 1745 collected and investigated cases. The records of these cases, however, were so incomplete and unsatisfactory that for some of the points entirely too little data were obtained to form the basis for conclusions. In order to overcome this difficulty the committee recommended to this Association a standard form for the record and preservation of fracture data, requested that it be made the official form of the Association, and that it be adopted by all Fellows of this Association and by the hospitals with which they were connected.

The Association adopted the form. It was also adopted by the surgical section of the American Medical Association, by several State medical societies, by the U. S. Army Medical Department, by the Compensation Board of Pennsylvania and by numerous hospitals and associations.

The chairman sent out several thousand copies of these forms to the various associations, societies, departments, hospitals and individuals. The net results have been the reception of reports of 327 additional cases up to date. Of these, many were so incompletely filled out that they were useless.

The committee feels, therefore, that with so few additional data it can offer to the Association very little more toward the standardization of the treatment and the average time of disability of fractures of the several regions of the long bones in the several age periods than it did in the preliminary report.

The little additional evidence, all of which has been worked out, except a few cases left over, by a Fellow who is in active military service, goes to confirm the conclusions of the preliminary report. The committee finds:

1. The results are best in the age period under fifteen years. Conservative treatment is generally effectual during this period.

2. Good anatomical restitution of a fractured long bone always results in the best functional result and has the shortest period of disability.

3. While few open operations are reported under the fifteen-year age period, it seems to make little difference in the results, except in senile cases (where it is unfavorable), what the age period is when the operation is done.

4. The end-results of non-operative and operative treatment of compound fractures show very little difference in the anatomical result, but the functional results are better after operative treatment,[1] except in compound fractures of the shafts of both bones of the leg; here the reverse seems to be true.

The age period, except in senile cases, has no marked effect on the result of the treatment.

[1] The period of disability is, however, longer by three or four weeks.

5. The average period of disability (that is, the time lost from work) in simple fractures is as follows:

For fracture of the shaft of the humerus	14.0 weeks
For fracture at the head and neck of the humerus	11.5 "
For fracture at condyles of the humerus	9.0 "
For fracture of the shaft of both bones of the forearm	10.8 "
For fracture of the femur, all sites	6.2 months
For fracture of the leg, all sites	4.9 "

NOTE.—This determination must still be held as not quite conclusive on account of the comparatively few clear reports on this point. The chairman has verified these disability periods in something less than 100 of his own cases and finds them substantially correct.

Periods of disability were not recorded accurately in the majority of the reported cases and very seldom in compound fractures.

For compound fractures the average period of disability is as follows:

For fractures of the femur	13 months
For fractures of the leg	6 "
For fractures of the upper extremity	4 "

6. The humerus should show not more than 1 cm. shortening and no appreciable angulation. Musculospiral paralysis should not result.

The forearm bones should show no appreciable shortening and pronation and supination should be unhindered. Function should always be good and no lasting pain result.

Fracture of the shaft of the femur should not result in shortening greater than 2 cm., nor in a fixed position of angulation or rotation which will affect the joints and require new habits of balancing or tilting of the pelvis; joint function should be good. No permanent disability of the affected member should result. Fracture of the shaft of the bones of the leg should result in no appreciable shortening and no angulation or rotation. Joint function should be preserved.

7. There is no method or splint universally applicable, nor has any given splint or apparatus proved its superiority. All depends upon the discrimination of the surgeon and the manner in which the apparatus is applied and maintained.

It is evident that traction methods are most frequently unskilfully employed. As a rule, too little weight is used. The gauge of the proper weight required is that necessary to overcome the shortening. This should be determined by careful daily measurement. Traction methods require, as a rule, counter-traction.

Plaster casts and molded splints are especially indicated and useful after a fracture has been satisfactorily reduced.

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